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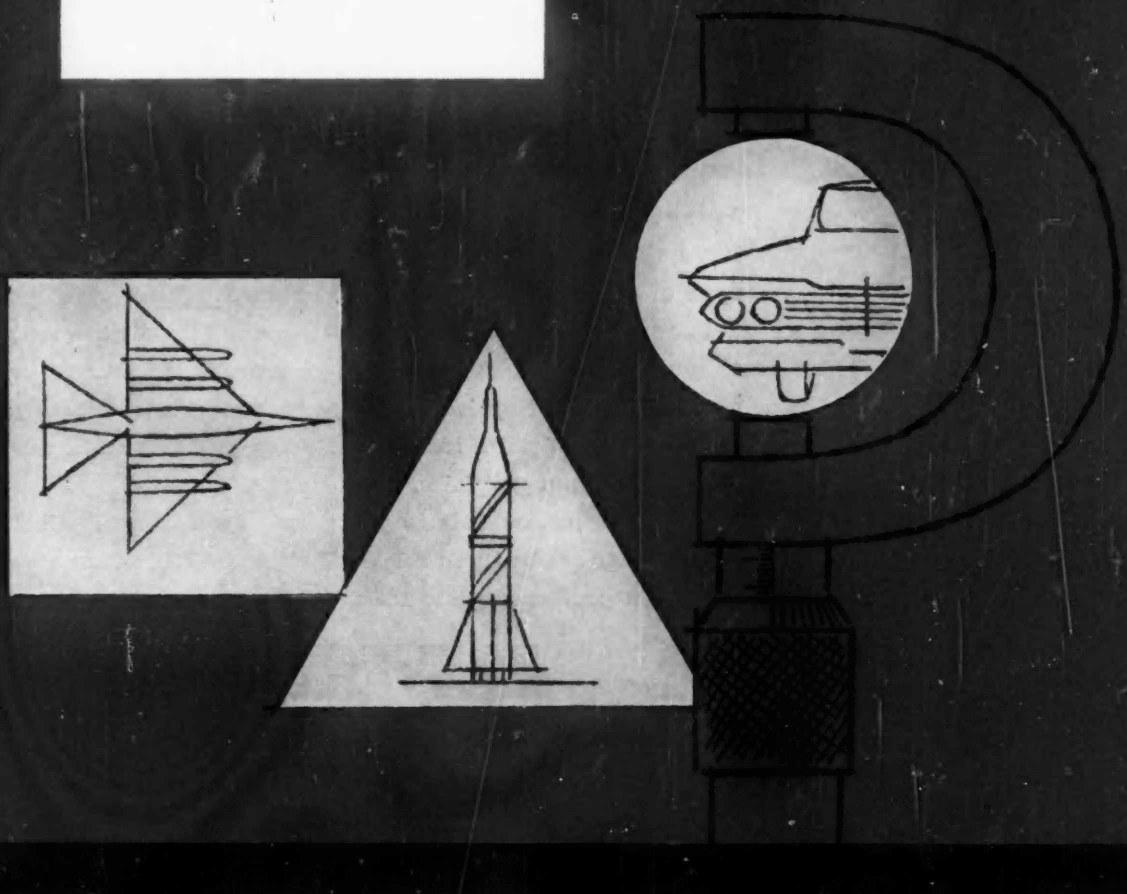
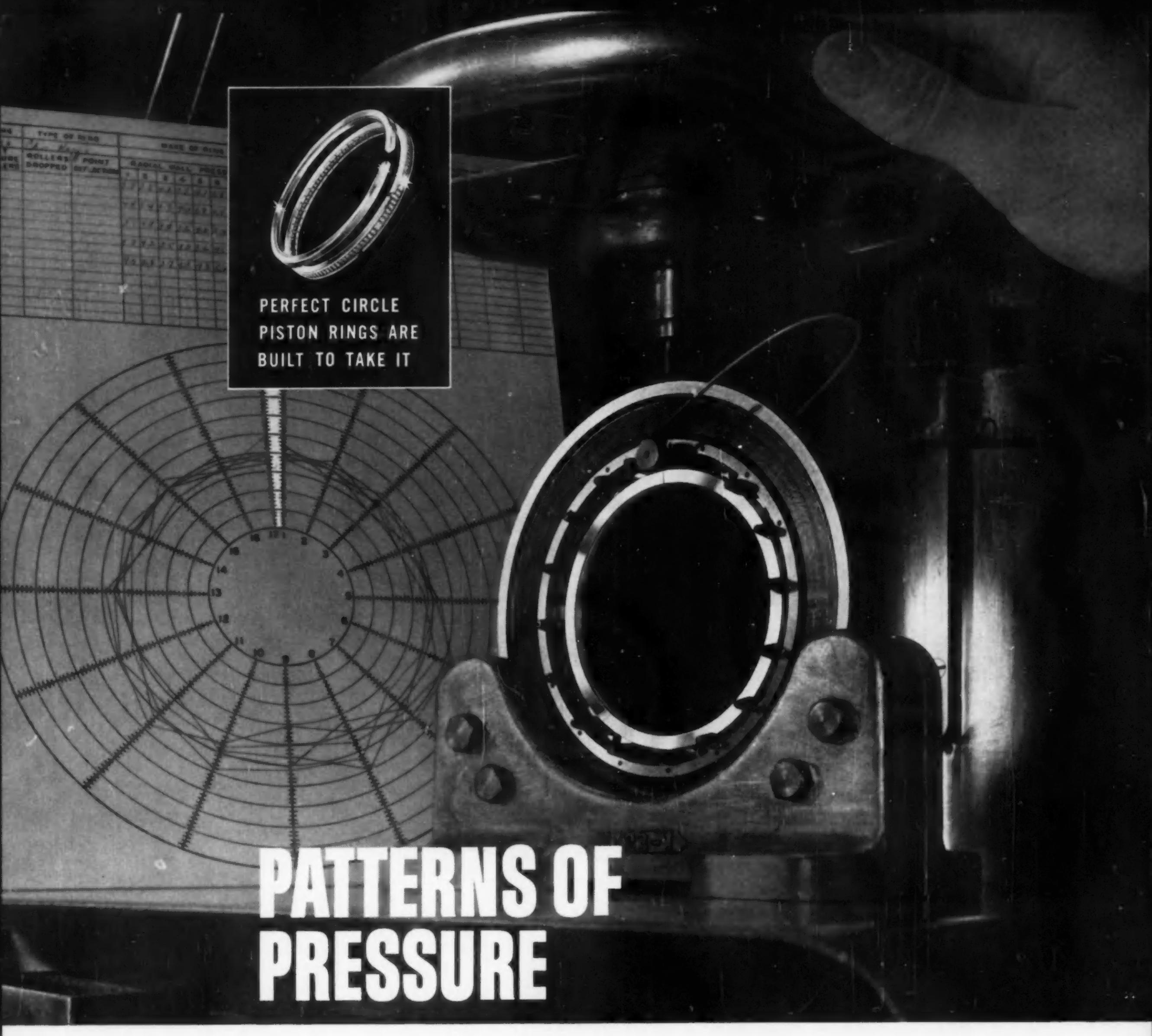
SAE JOURNAL





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Contents • January, 1961

INDEX of 1961 SAE Journal technical articles will appear in the December 1961 issue

To order papers on which articles are based, see p. 6.

Continued on page 2

Contents • January, 1961 • Continued

More on page 1

To order papers on which articles are based, see p. 6.

The Society is not responsible for statements or opinions advanced in papers or discussions at its meetings or in articles in SAE Journal.

A complete index of all Journal technical articles, from January through December, will appear in the December issue. All Journal technical articles are indexed by Engineering Index, Inc. SAE Journal is available on microfilm from University Microfilms, Ann Arbor, Mich.

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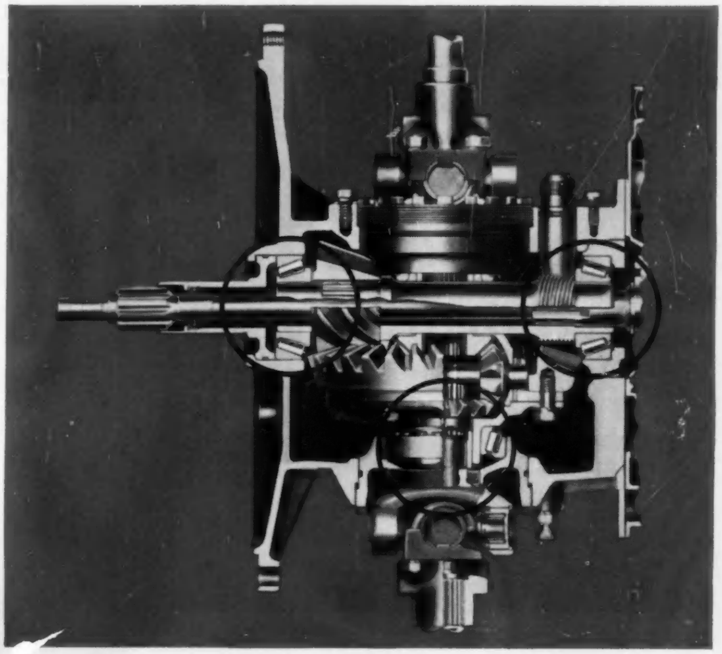
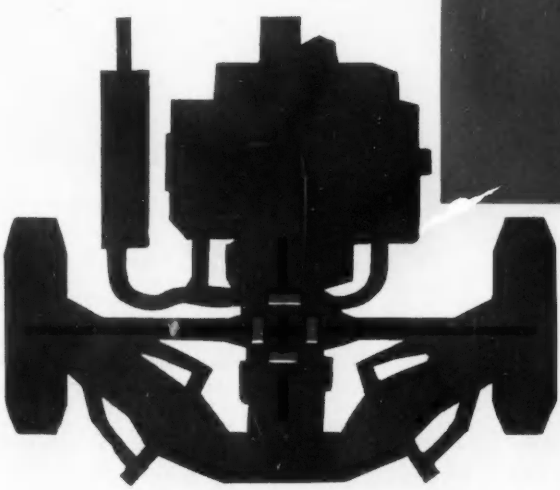


In the Corvair's compact design, the pair of Hyatt taper bearings supports the pinion gear. These bearings, along with another pair of Hyatts which support the differential carrier and ring gear, assure accurate gear contact.



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To order the SAE papers digested here, circle the numbers in the "Readers Information Service" blank on p. 6 corresponding to the numbers appearing after the titles of the digests of the papers you want.

AEROSPACE

Method for Controlling Time-Variable Aerodynamic Heating and Loads in Structural Testing, G. R. REWERTS, P. J. SWANSON. Paper No. 288A. Method at Convair-Astronautics and testing aerodynamic heating effects on material and structural strength, structural deflection, and functional operation of aircraft and missiles consisted of open loop system which applied d-c voltages to d-c motors which drove potentiometers controlling power to heat banks; motors driving linear actuators varied settings of pressure regulators to control hydraulic pressures; design of open loop programmer and its application to ICBM missiles.

Testing Techniques for Elevated Temperature Structures, S. L. SHAW, C. H. STEVENSON. Paper No. 228B. Techniques and specialized test equipment evolved at Douglas Aircraft Co. that permit simulation in laboratory of all conditions of aero-space vehicles thermal, physical and chemical environments; equipment to conduct stress-temperature-time spectrum tests of materials; resistance heating techniques; material test set-up employing high intensity radiator; "ANDERSOMETER" used to determine thermal properties of different materials is based on principle of heat transfer from material by radiation only.

Methods of Establishing and Presenting Environmental Design Criteria for Air Vehicles, J. E. STEIN. Paper No. 228D. Environments to consider in process of establishing design criteria are natural environments, relating to temperature, solar radiation, humidity, pressure, sand and dust, etc., and induced environments which are result of air vehicle operation; effects of aerodynamic heating, vibration, acoustical noise, and acceleration establish environments peculiar to particular vehicle; some of these factors are discussed with emphasis on temperature criteria.

Future Reliability Concepts and Ramifications, R. H. HERSHKOWITZ. Paper No. 229A. Paper examines several reliability concepts applicable to vehicles of near future and points way for further conceptual studies; consideration given to cost, safety, and payload-carrying capability; economic approach to intergrated component subsystem, and combined systems testing is offered as means for providing high confidence assessments and improvements to given design.

Reliability Concepts for Future Transports, H. W. ADAMS. Paper No. 229B. For commercial transport aircraft, human safety is aspect of reliability of first importance, defined as probability of flight completion without fatality or injury; second in importance are trip completion and schedule reliability; review of various approaches to designing safe aircraft; reliability analysis and philosophy of safety design as applied by Douglas Aircraft Co. is summarized; use of simulators to test various cockpit arrangements to reduce frequency of design-induced pilot error accidents.

Evaluation of Relationship Between Reliability, Overhaul Periodicity, and Economics in Case of Aircraft Engines, F. S. NOWLAN. Paper No. 229C. Reference made to FAA policy under which no overhaul time extensions are permissible unless failure rate is less than defined number; validity of policy is examined and quantitative relationship which exists in case of reciprocating engine between probability of requiring unscheduled removal for premature overhaul, and operating time since overhaul; first relationship is used to determine relationship between direct maintenance costs and overhaul periodicity.

Philosophy of Design Safety Provisions in Complex Weapons, W. L. JOHNSTON. Paper No. 229D. Most logical approach to problem of measur-

Continued on page 6

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4	127	149	172
7	128	150	173
8	129	151	175
9	131	152	177
10	132	153	178
11	133	154	179 top right
12	134	155	179 top left
13	135	156	180 left
14	136	157	181
15	137	158	182
16	138	159	183 right
17	139	160	183 left
18	140	162 right	184
19	141	162 left	185
20	142	164	187
21	143	165	188
22	144	166	Inside front cover
24	145	167 top	Inside back cover
124	146	168	Outside back cover
125	147	169	

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Briefs of SAE PAPERS

Continued from page 5

ing safety is offered by field of reliability using measures of probability and statistics; advantages that can be gained from quantification of safety; possible method is outlined in six steps which will enable designer to compute estimate of inherent safety of system.

Design of Experiment in Determination of Shock and Vibration Environment, J. E. BARKHAM. Paper No. 231A. Parametric influences of ballistic missile during flight are considered and dynamic environment can be determined in probability terminology of means and extremes; flight vibration characteristics, identified as transient, random or sinusoidal; expected losses in locating pickup for vibration and shock measurements; functions of designing experiment and coordination and integration; established procedures control experiment to highest degree to allow for statistical treatment.

Presentation and Analysis of Shipboard Shock Data, S. C. ATCHISON. Paper No. 231B. Underwater explosion tests were conducted at David Taylor Model Basin to determine shock motions to which ship's structure and equipment are subjected under combat conditions; velocity-time histories, displacement-time histories, peak accelerations, and shock spectra are some of means of presenting shock data; shock measuring instruments, recording systems and data handling systems; several analysis programs for IBM-704 computer are described; comparison of methods.

Processing Missile Flight Vibration Data, J. N. CHRISTIANSEN. Paper No. 231C. Equipment, methods and procedures used at Lockheed Missiles and Space Div.; most of vibration data handled is telemetered on conventional FM/FM carrier systems; under development is PAM/FM system which has eight vibration channels of 2-kc response; conversion and processing equipment is assembled into two stations each having two tape recorders and FM conversion capabilities; Flight Data Processing, and Data Systems Operation and Development; procedures to determine accuracy of data.

Correction and Statistical Analysis of Missile Flight Vibration Data, M. D. LAMOREE. Paper No. 231D. Use of statistical techniques in describing missile vibrations and in predicting extreme vibration levels within established limits of confidence as applied by Lockheed Aircraft; concepts used to characterize random vibrations are rms acceleration and Power Spectral Density of accelerations; steps in systematic procedures divided into those directed toward improving validity of flight data and those utilizing flight data to establish design criteria and test specifications.

Comparison of Four Auxiliary Power Systems for Short-Duration Missile Applications, D. T. A. MILLER. Paper No. 232A. Analysis of qualitative effects of major parameters, and variables on performance of flywheel, silver-zinc battery, and solid propellant; bottled gas is included for comparison; paper deals with lower duration limit in which region duty cycle of 100 sec at average output of 10 hp is typical; system components and energy source; it appears that by designing to specific requirements silver-zinc batteries are adaptable to most missile applications, and probably most reliable power source available.

Development and Tests for Achieving Reliability and Reproducibility of Solid Propellant Gas Generators, K. F. MILLER. Paper No. 232B. Applications comprise auxiliary power units in missiles, aircraft and space vehicles; factors to consider; propellant properties; process flow outline for production, process and quality control techniques applied at North American Aviation; purpose and design of Tartar and Terrier gas generator, liquid engine turbine starter and jet engine starter cartridge, pointing out problem areas; future developments.

Utilization of Solid Propellant Power Supplies for Ground to Air Rapid Firing Missiles, M. VOYTISH, Jr. Paper No. 232C. Understanding of missile weapon system requirements, performance of grain, components and controllers, and power supply outputs will per-

Continued on page 91

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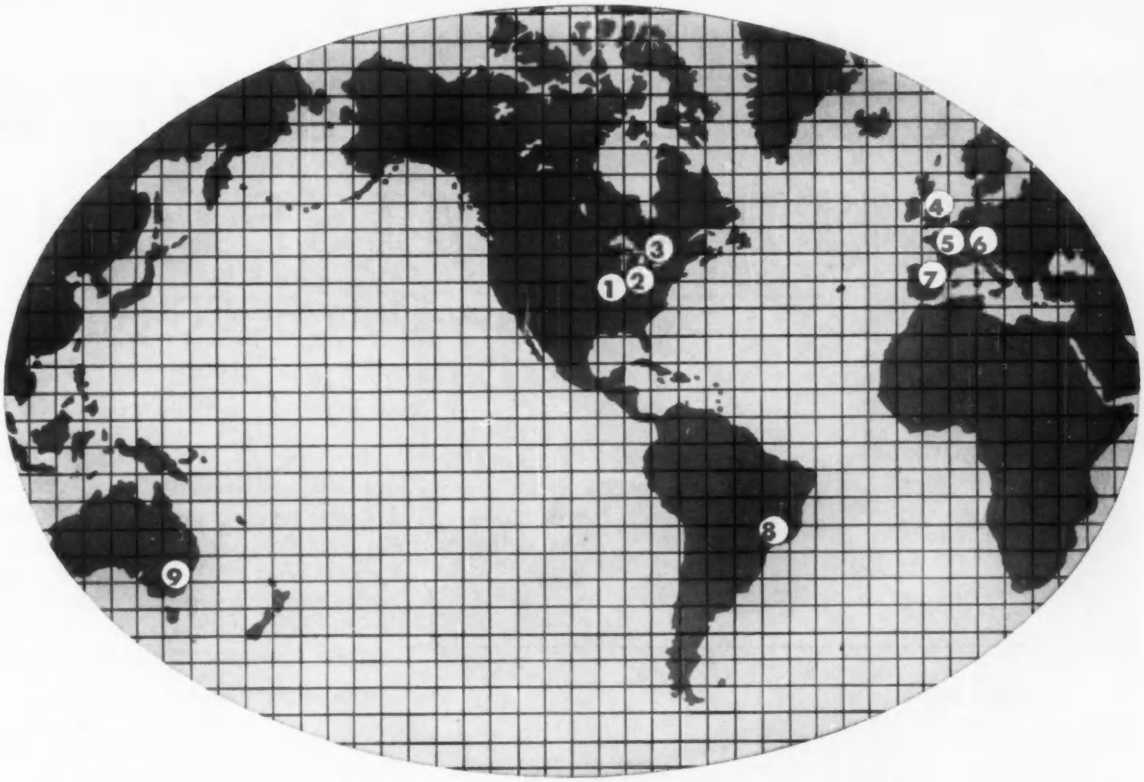
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6
7
8
9

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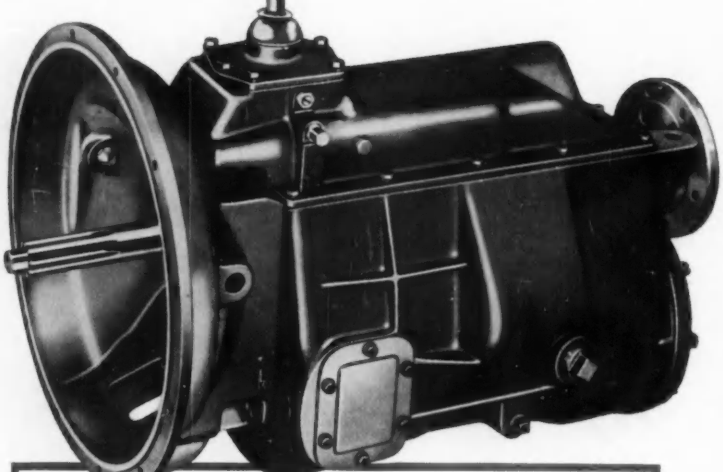

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NOTE: The 8031 and 8035 Series Spicer auxiliary transmissions have been augmented by a new underdrive ratio of 1.19 to 1 to better complement the ratios of the new Series 8000 direct-on-fifth transmissions.

For complete information on the new Spicer 8000 Series transmissions, write to Dana Corporation, Toledo 1, Ohio.

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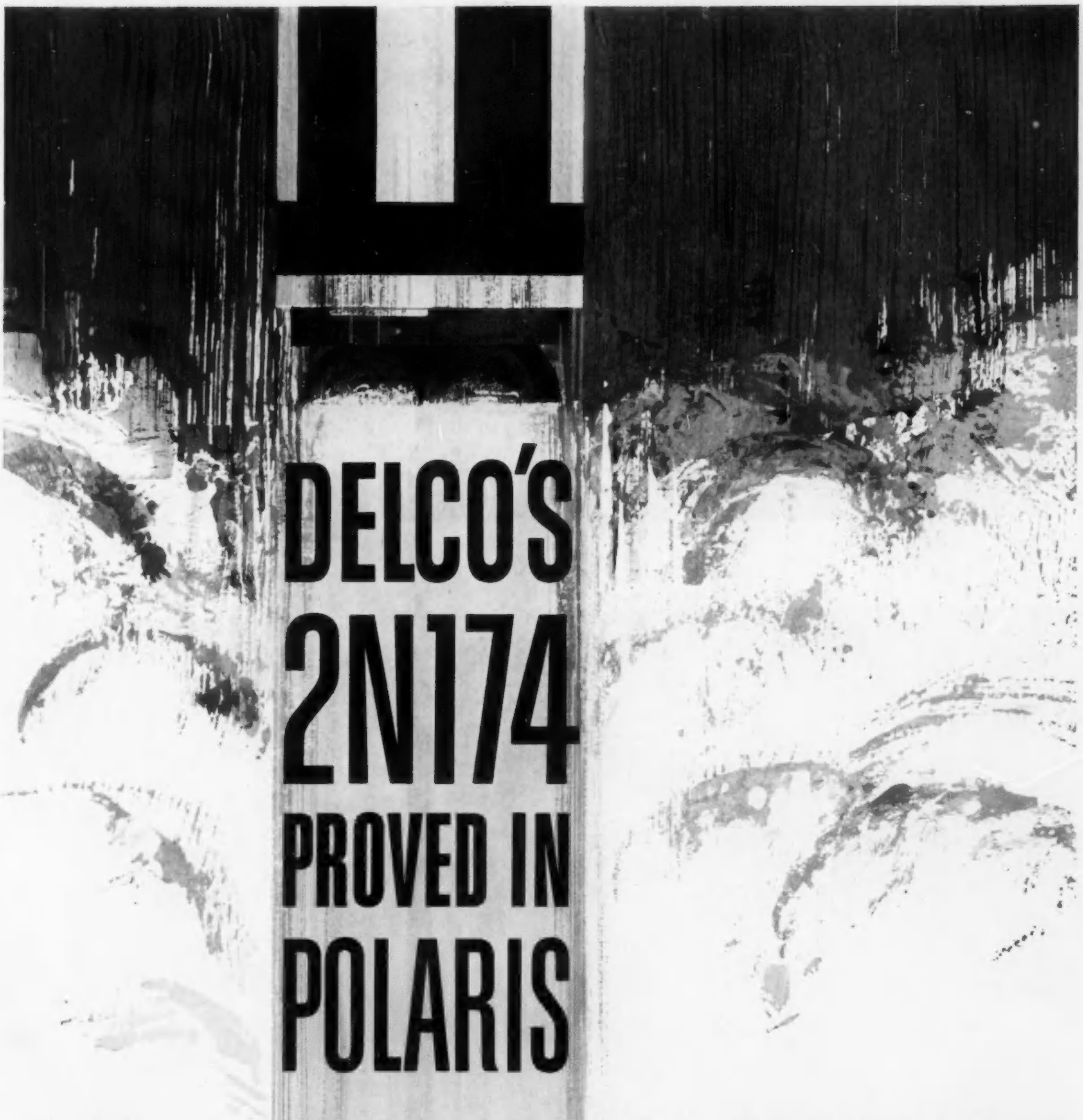

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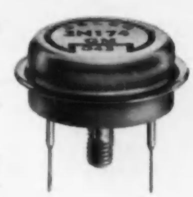

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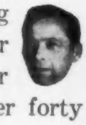

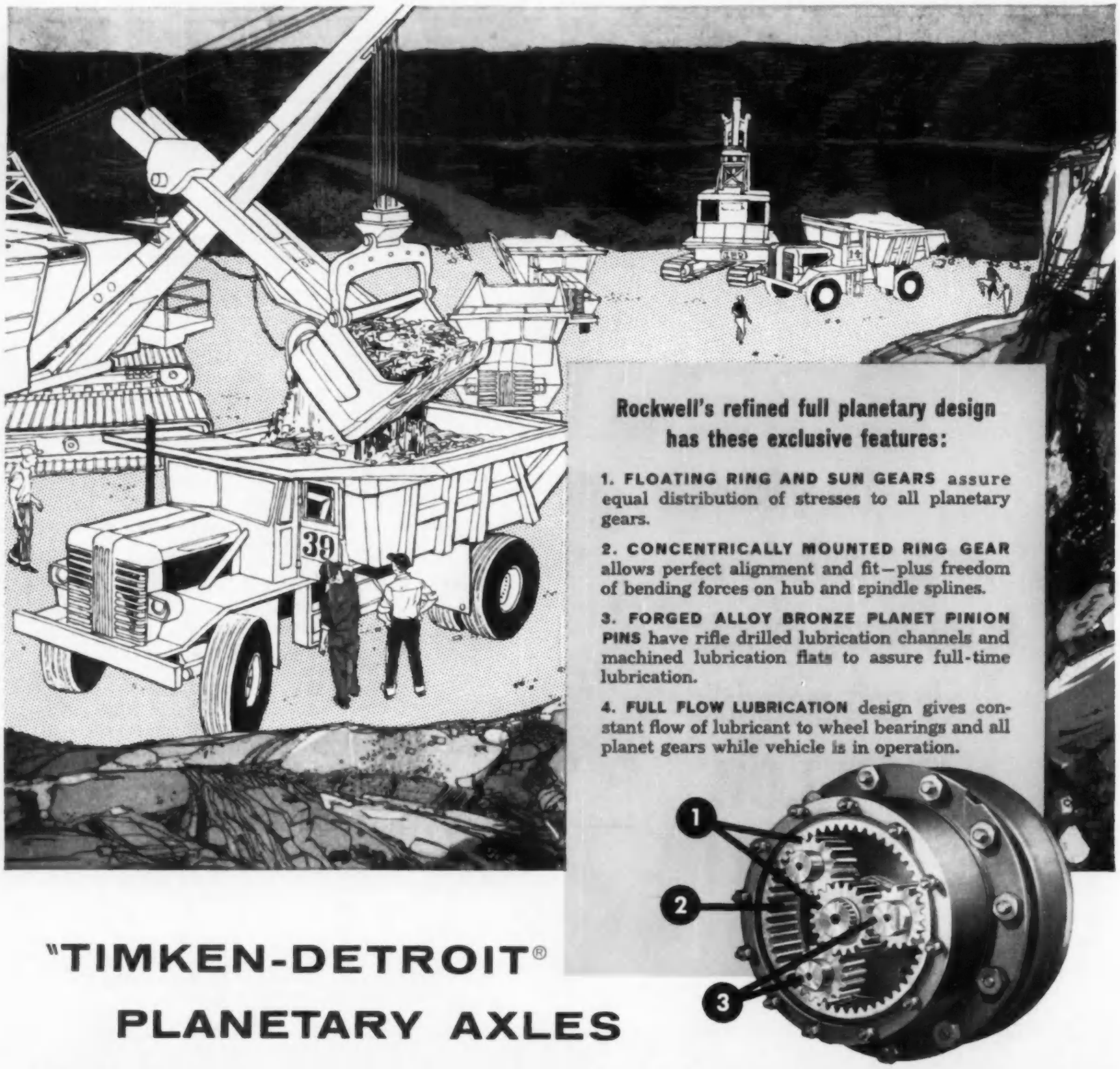

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For Sake of Argument

Disciplining Imps . . .

WHEN A PROBLEM keeps plaguing us, as likely as not we haven't made the trouble clear to ourselves. Chances are we haven't seen the question for what it really is; haven't made it crystal clear for analysis.

The difficulty often lies in failure to "package" the problem. We find our thought disquieted by a bevy of specific, semi-related posers. . . . Like a hoard of unruly brothers and sisters, they scamper back and forth through our troubled consciousness. They come nearest to orderliness when they get to going round and round and round. Such little light as is cast on the revolving imps flickers as a fall sunset through half-bare maples.

We begin to get somewhere when we manage to see all the little imps as part of a single problem family . . . or decide that one of the little beggars is really the crux of the whole thing. If the latter, we see that, in straightening him out, we shall have established a pattern for straightening out the rest. The related problems have been packaged into one.

Then, we find, this one big problem is much, much easier to handle than the score of little ones. We can wrap our mind around this single, neatly-packaged point . . . relate it to principles — which underlie successful solution of any problem.

Once we've come this far, the road down which to march our disciplined imps has unfolded pretty clearly. . . . We walk that road surely when we insist on a solution that conforms to principle. We chance getting lost again when we search for principles which can be applied to our solutions.

Norman G. Shidle

Engineers' Guide to Cobo Hall

at the SAE International Congress and Exposition of Automotive Engineering—Detroit January 9-13, 1961

FOLLOWING are 15 pages of information designed to make your visit to Cobo Hall more pleasant ———►

You'll want to attend the SAE International Congress and Exposition of Automotive Engineering . . .

. . . at Detroit's new Cobo Hall, January 9–13, 1961. It marks the first time in history that engineers from every phase of the giant automotive industry — ground and flight vehicles — will gather at one time . . . in one place . . . under one roof. Persons from all over the world are expected to attend.

Plan to:

- attend some of the many sessions planned to tip you off on what's ahead in your field. There will, for example, be an all-day symposium on "How Will the Passenger Travel In Mass Transportation on 100 to 200 Mile Trips In The Late 1960's?" Will it be ground-effect machines, monorail cars, V/STOL craft, conventional aircraft, diesel trains, buses, or some entirely new vehicle? Other sessions will cover successors to the piston engine, new materials, tools for "hot labs," and hundreds of other subjects.

- inspect the products and developments of the more than 500 exhibitors who will augment the technical program with the latest in manufacturing techniques, systems and components, materials, and powerplants. In the 4½-acre display area, you'll have the opportunity to question the technical representatives manning these booths, and to get the answers to your problems.

- visit the Science Pavilion and inspect vehicles engineers have developed as a result of breakthroughs made in the last few years.

- stop in at the SAE booths. The SAE Information Center will be located in the Science Pavilion. SAE Journal will occupy booth 1832. An SAE General Publication booth will be located at the entrance to Cobo Hall. SAE staff representatives will be on hand to tell the SAE story and to answer any questions you may have.

How to Get to Cobo Hall . . .

Cobo Hall's main entrance faces Washington Boulevard, which runs north from this point to Grand Circus Park. It is bounded on the west by First Street, on the east by Washington Boulevard, and on the north by Larned Street.

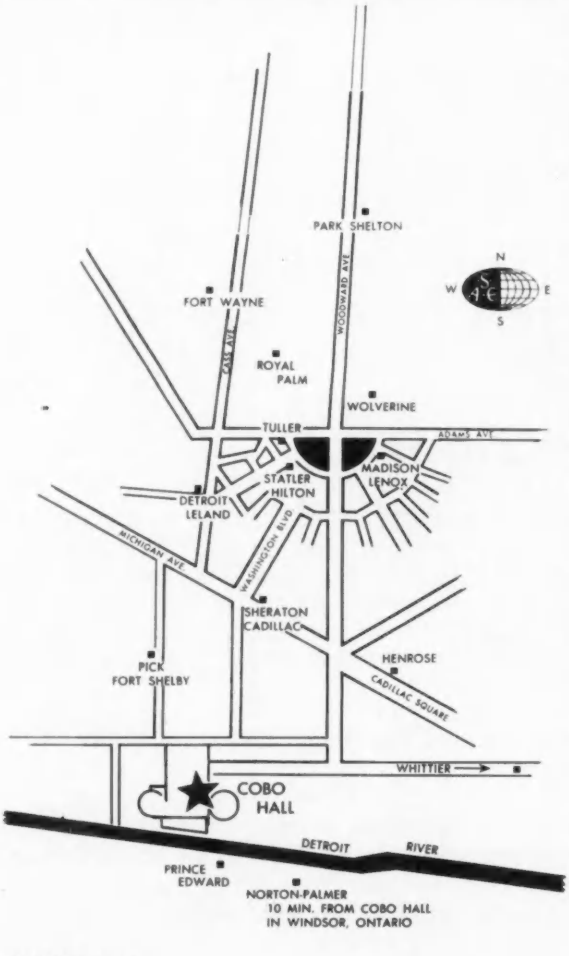
By Car

Cobo Hall is a terminal point on Detroit's new expressway network, which knits city, suburban, and highway auto traffic, and channels it directly into the Civic Center at high speeds.

By using existing thruways and expressways, a motorist could drive to the parking deck on the hall's roof, or to one of the underground parking garages with scarcely a stop for a traffic signal, from many places on the Atlantic Coast between northern Maine and the Potomac River. It is similarly accessible to motorists driving east from Chicago.

In Detroit the Edsel Ford Expressway from the west, and the John C. Lodge Expressway from the northwest, lead directly to the site. Helical ramps from the John C. Lodge Expressway lead directly to the hall's roof.

Within the boundaries of Cobo Hall are five major parking units with space for 3,290 cars. The Cobo Hall roof deck accommodates 1,150 cars; Cobo Hall garage (inside the hall), 600 cars; Convention Arena underground garage, 400 cars; Cobo Hall surface lot, 440 cars; and Ford Auditorium underground garage, 700 cars.



The roof of Cobo Hall is accessible by means of a spiral ramp on the west side of the building, which can accommodate three lanes of traffic. The First Street ramp, which is directly accessible to both the John C. Lodge Expressway and First Street, runs into the spiral ramp. (There is also provision for a heliport on the roof.)

The Cobo Hall garage is underground at the north end of the building. The Convention Arena garage is a similar structure at the east end of the hall. The surface parking lot is just west of the building and the spiral ramp. The Ford Auditorium underground garage is about ¼ of a mile east of the Convention Arena on Jefferson Avenue.

Other parking lots which are close by can accommodate 4,000 cars. Across from Cobo Hall on Larned Street is a lot for 550 cars. A block away, on Congress Street are two lots for 500 and 150 cars, and two blocks away on Washington Boulevard is a lot accommodating 150 cars.

The Greyhound Bus Terminal, which has parking facilities for 600 cars, is less than ½ mile east of Cobo Hall on Larned Street. Across from the terminal on Congress Street is a lot accommodating 700 cars.

By Bus

For your convenience shuttle buses (the Downtown Loop Line) will pick up passengers from the Sheraton-Cadillac, Statler-Hilton, Detroit-Leland, and Pick-Fort Shelby hotels. The buses will operate every 10 minutes during convention hours and will cost 20 cents.

Coaches will load and unload at the river entrance of Cobo Hall on Civic Center Drive.

The Woodward Line will be extended west on Jefferson to Cobo Hall.

Five buses will be operating for the Annual Dinner on Wednesday night, January 11, no fee.

By Foot

Within walking distance of Cobo Hall are principal hotels, as well as bus, rail, and airline bus terminals.

The Statler-Hitlon Hotel is less than a mile north of Cobo Hall on Washington Boulevard. The Sheraton-Cadillac Hotel is about ½ mile north on Washington Boulevard. The Detroit-Leland Hotel, which is north of Cobo Hall on Larned Street, is about ¾ of a mile from the hall.

By Boat

One could arrive by yacht or steamer and toss mooring lines around the bollards in front of the hall's southern facade, which faces the Detroit River.

Don't forget to register!

The registration area will be at the main entrance of Cobo Hall (see floor plan on p. 29), and will be open after 8:00 a.m. daily.

There is no registration fee for SAE members attending the SAE International Congress and Exposition of Automotive Engineering, nor for members of the armed forces and other government employees, students, and faculty members.

Nonmembers of the Society can attend the Congress and Exposition and enjoy many of the other advantages of membership, temporarily, by paying the registration fee of $3.00 per day or $12.50 for five days. Nonmembers planning to visit the Exposition only will be required to pay an Exposition registration fee of $1.00.

All members and nonmembers must register, and must wear an official registration badge at all times.

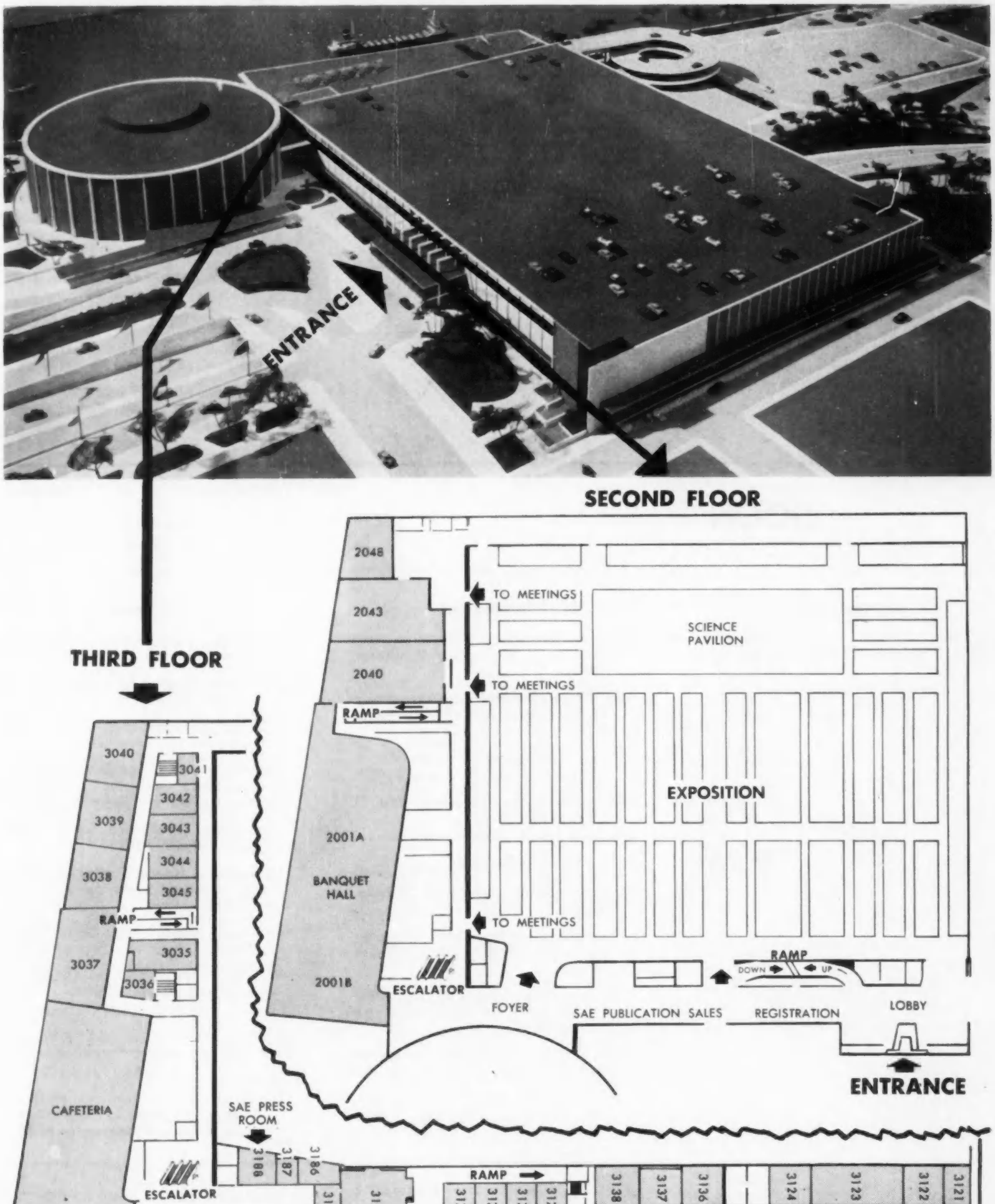
Engineers' Guide to Technical Sessions

All technical sessions will be held in meeting rooms located on the second (ground) and third floors of Cobo Hall (see floor plan on p. 29 and technical session program on p. 30–31). Ramps with long, easy grades permit free flow of traffic from floor to floor. Two of these ramps (one at the west side of the hall and one at the east) are wide enough to accommodate even the largest of motor vehicles, as well as pedestrian traffic. Another ramp, at the southern end of the building is for pedestrians only.

There are elevators in the southwest and northeast corners of Cobo Hall, and escalators in the southeast corner.

Preprints of papers presented at the technical sessions and other special publications will be available for purchase at the SAE preprint booth located to the left at the main entrance of Cobo Hall (see floor plans on p. 29 and 32). Preprints are 50 cents per copy. Special publications are individually priced.

Meeting Rooms at Cobo Hall



Engineers' Guide

A M

Monday—Jan. 9

9:00 a.m. (Four Sessions)

- Future Short-Haul Transportation: Ground vs Air — Part I **(Room 2040)**
- Seating and Interior Dimensioning of Passenger Cars — Part I **(Room 2048)**
- Things You Ought to Know About Batteries — Part I **(Room 3038)**
- Gas Turbine Compressors — Part I **(Room 3037)**

Tuesday—Jan. 10

9:00 a.m. (Seven Sessions)

- Effects of Wet or Icy Runways and How to Clear Them **(Room 2048)**
- Alternators and Storage Batteries for Small Engines **(Room 3040)**
- Development in Heat Exchangers for Aerospace Vehicles and Reactors — Part I **(Room 2040)**
- Generating New Ideas on Production Processes **(Room 3039)**
- Wire Cord Tires **(Room 2043)**
- Thermodynamics and Combustion **(Room 3037)**
- How Non-Metallic Material Break-Throughs After Body Design **(Room 3038)**

NOON

Tuesday—Jan. 10

12:00 Noon **Luncheon**

SAE Honors Its Overseas Guests (Room 2001)

P M

Monday—Jan. 9

1:15 p.m. (Four Sessions)

- Future Short-Haul Transportation: Ground vs Air — Part II **(Room 2040)**
- Seating and Interior Dimensioning of Passenger Cars — Part II **(Room 2048)**
- Things You Ought to Know About Batteries — Part II **(Room 3038)**
- Gas Turbine Compressors — Part II **(Room 3037)**

3:30 p.m. (Five Sessions)

- Ground Effect Machines **(Room 3039)**
- Compression Temperature Measurements in Diesel Engines **(Room 3040)**
- An Improved Method of Specifying Rubber Parts for Automotive Use **(Room 3045)**
- The XM521 Experimental Research Vehicle **(Room 2043)**
- Shortening the Time Cycle for Automobile Body Tooling **(Room 3035)**

Tuesday—Jan. 10

2:30 p.m. (Eight Sessions)

- Passenger and Cargo Handling Equipment **(Room 2048)**
- Corrosion-Proof All-Metal Bodies **(Room 3038)**
- Automobile Electrical System Developments **(Room 3040)**
- Development in Heat Exchangers for Aerospace Vehicles and Reactors — Part II **(Room 2040)**
- Designing Trucks for Super Highways **(Room 2043)**
- Laboratory Knock-Testing Methods of Improved Significance **(Room 3037)**
- Standard Measurement Units **(Room 3035)**
- Practical Applications of Operations Research **(Room 3039)**

4:30 p.m.

Student Engineer Program **(See Special Student Program on P. 38.)**

EVE

Tuesday—Jan. 10

8:00 p.m. (One Session)

- The Rotary Combustion Engine **(Room 2040)**

to Technical Sessions . . .

Wednesday–Jan. 11

9:00 a.m. (Six Sessions)

- Abnormal Combustion — Part I **(Room 2040)**
- New Uses of Isotopes in Research **(Room 2048)**
- New Powerplants for Trucks and Trains **(Room 3038)**
- Metallurgical Investigation and Accelerated Testing **(Room 2043)**
- Automatic Transmission — 1961 **(Room 3037)**
- The Automotive Industry Tackles Reliability **(Room 3035)**

1:15 p.m. (Five Sessions)

- Abnormal Combustion — Part II **(Room 2040)**
- Useful Effects of Ionizing Radiation **(Room 2048)**
- Multifuel Engines **(Room 3038)**
- Automobile Suspension Systems **(Room 3037)**
- Reliable Electrons — Part I **(Room 3040)**

3:30 p.m. (Five Sessions)

- Fluid Gearing — The L. Ray Buckendale Lecture **(Room 2043)**
- Breakthroughs in Engineering Education in the 60's **(Room 3039)**
- Military Need for Small Power Sources **(Room 3045)**
- Securing Maximum Flexibility of Production Equipment **(Room 3035)**
- Reliable Electrons — Part II **(Room 3040)**

6:30 p.m.

SAE ANNUAL BANQUET (Room 2001)

Thursday–Jan. 12

9:00 a.m. (Six Sessions)

- Project Moonbeam — A 10,000 lb-payload Lunar Vehicle — Part I **(Room 3037)**
- Motor Oil Development Criteria **(Room 2040)**
- Breakthroughs in Computers **(Room 3040)**
- Excavating by Nuclear Blasts **(Room 3038)**
- Reducing Automobile Interior Noise — Determining Structural Requirements **(Room 2048)**
- Containerization of Freight **(Room 2043)**

1:15 p.m. (Four Sessions)

- Project Moonbeam — Part II **(Room 3037)**
- Effect of Fuel Cell Powerplant on Future Automobile Design **(Room 2048)**
- Disc Brakes and Anti-Skid Braking Devices **(Room 2043)**
- SAE Fuel Filter Test Methods — Part I **(Room 3040)**

3:30 p.m. (Five Sessions)

- Project Moonbeam — Part III **(Room 3037)**
- Test Tracks Engine Air Cleaners **(Room 3038)**
- New Engines for 1961 Passenger Cars — Part I **(Room 2040)**
- SAE Fuel Filter Test Methods — Part II **(Room 3040)**
- Transistorized Ignition **(Room 3039)**

8:00 p.m. (One Session)

- New Engines for 1961 Passenger Cars — Part II **(Room 2040)**

Friday–Jan. 13

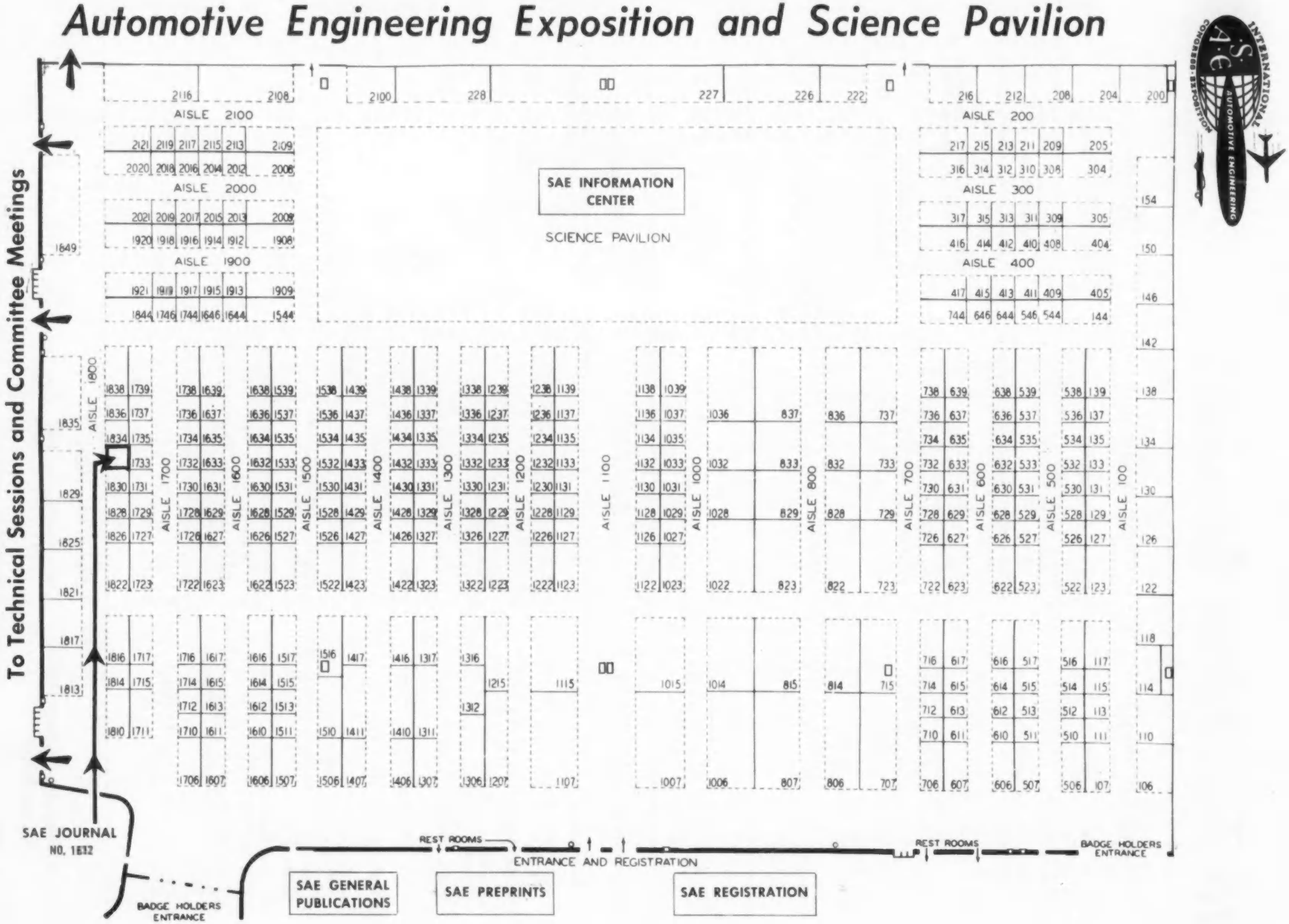
9:00 a.m. (Five Sessions)

- Transmission Workshop — Part I Transmission Friction Component Design **(Room 2043)**
- Theory of Vehicular Traffic Flow — Panel **(Room 2048)**
- Bus Development, Operation, and Maintenance **(Room 2040)**
- Fuel Cells and Mobile Reactors **(Room 3037)**
- Road-Vehicle Loading Relationships **(Room 3038)**

2:00 p.m. (Three Sessions)

- Transmission Workshop — Part II Transmission Oil Pump Design **(Room 2043)**
- Compact Trucks for Utility Use **(Room 2040)**
- Magnetohydrodynamics **(Room 2048)**

Automotive Engineering Exposition and Science Pavilion



Engineers' Guide to Committee Meetings

The following is a partial listing of committee meetings to be held at the meeting. All committee rooms are located on the third floor of Cobo Hall unless otherwise stated. **(See floor plan on p. 32 for room locations.)**

Administrative Committee Meetings

1960 and 1961 Board of Directors—Fri., 9:00 a.m. (meeting) and 12:30 p.m., (luncheon), Crystal Ballroom, Sheraton-Cadillac Hotel

CEP Group Leaders—Mon., 12:00 noon (luncheon), Room 3036

Engineering Activity Board—Thurs., 1:30 p.m., Room 3042
Executive Com.—Thurs., 12:00 noon (luncheon), Room 3041
Activities Scope Review Com.—Thurs., 9:00 a.m., Room 3041
Meetings Planning Com.—Tues., 9:00 a.m., Room 3041
Publications Advisory Com.—Tues., 2:30 p.m., Room 3041

Membership Com.—Thurs., 9:00 a.m., Room 3175
Engineering Activity Membership Program Subcom.—Tues., 3:30 p.m., Room 3136
Sections Membership Program Subcom.—Wed., 1:30 p.m., Room 3176
Technical Membership Program Subcom.—Mon., 1:30 p.m., Room 3041

Membership Development Conference—Thurs., 12:00 noon (luncheon), Room 3043

Past Presidents Advisory Com.—Tues., 6:00 p.m. (dinner), Sheraton Room, Sheraton-Cadillac Hotel

Placement Com. Exec. Com.—Thurs., 12:00 noon (luncheon), Room 3045

Sections Board—Wed., 8:00 a.m. (breakfast), Room 3175
Executive Com.—Tues., 2:30 p.m., Room 3178
Administrative Com.—Mon., 9:00 a.m., Room 3041
Area Coordinators Conference—Mon., 12:00 noon (luncheon), Room 3177
Finance Com.—Mon., 1:30 p.m., Room 3176
Student Activities Com.—Tues., 8:00 a.m. (breakfast), Room 3177

Sections Officers Conference—Wed., 12:00 noon (luncheon), Room 3175

Student Activities Conference—Tues., 12:00 (luncheon), Room 3177

Technical Board—Thursday, 10:00 a.m. Room 3137, 12:00 noon (luncheon), Room 3138
Executive Com.—Thurs., 8:00 a.m. (breakfast), Room 3177

Activity Committee Meetings

Air Transport Act.—Wed., 9:00 a.m., Room 3177

Aerospacecraft Act.—Wed., 3:30 p.m., Room 3177
Subcom. on Right Approach to Reliability—Tues., 9:00 a.m., Room 3175

Aerospace Powerplant Act.—Wed., 1:30 p.m., Room 3177

Body Act.—Wed., 12:00 noon (luncheon), Room 3176

Computer Act.—Thurs., 12:00 noon (luncheon), Room 3036

Engineering Materials Act.—Wed., 3:30 p.m., Room 3044

Farm, Construction and Industrial Machinery Act.—Thurs., 1:30 p.m., Room 3177

Fuels and Lubricants Act.—Mon., 1:30 p.m., Room 3175
Steering Com.—Mon., 9:30 a.m., Room 3175

Nuclear Energy Act.—Fri., 2:00 p.m., Room 3176

Powerplant Act.—Tues., 2:30 p.m., Room 3042

Production Act.—Mon., 4:00 p.m., 3043

Science-Engineering Act.—Wed., 1:30 p.m., Room 3041

Transportation and Maintenance Act.—Wed., 9:00 a.m., Room 3138

Truck and Bus Act.—Thurs., 9:00 a.m., Room 3176

Technical Committee Meetings

Room assignments for Technical Committee Meetings will be available at the SAE Information Desk in Cobo Hall.

AE-4, Radio Interference—Thurs., 9:00 a.m.

Body Engineering Com.—Tues., 2:30 p.m.

Brake Steering Com.—Fri., 12:00 noon (luncheon)
Brake Subcom. II—Brake Linings—Tues., 9:00 a.m.
Brake Subcom. III—Dynamometer Test Code—Wed., 9:00 a.m.
Brake Subcom. IV—Brake Rating—Tues., 1:30 p.m.
Brake Subcom. V—Nomenclature—Wed., 9:00 a.m.
Brake Subcom. VI—Rating of Auxiliary Brakes—Wed., 1:30 p.m.
Brake Subcom. VII—Road Test Procedure—Wed. 1:30 p.m.
Passenger Car Road Test Subgroup—Tues., 9:00 a.m.
Brake Subcom. VIII—Bonding Brake Linings—Thurs., 9:00 a.m.
Brake Subcom. IX—Brake System Components—Thurs., 9:00 a.m.

Construction and Industrial Machinery Tech. Com.—Wed., 2:00 p.m.
Subcom. III—Yardage Ratings—Tues., 11:00 a.m.
Subcom. IV—Hydraulic Power Controls—Tues., 9:00 a.m.
Subcom. VI—Industrial Engine & Power Unit Standards—Wed., 9:00 a.m.
Subcom. XI—Tractor Mounted Side Booms—Wed., 9:30 a.m.
Subcom. XII—Test Codes—Tues., 9:00 a.m.
Subcom. XVI—Ease of Maintenance—Wed., 9:00 a.m.
Subcom. XVII—Crane Testing Procedures—Tues., 8:30 a.m.
Subcom. XVIII—Human Engineering—Wed., 12:00 noon (luncheon)

Electrical Equipment Com.—Thurs., 9:00 a.m.
Ignition Subcom.—Tues., 9:00 a.m.
Motors and Generators Subcom.—Tues., 2:30 p.m.
Vehicle Radio Interference Subcom.—Wed., 9:30 a.m.

Engine Com.—Tues., 9:00 a.m.
Clutch Housings, Clutch Mountings & Flywheels Subcom.—Tues., 2:00 p.m.
Filter Test Methods Subcom.—Tues., 9:00 a.m. and Wed., 9:00 a.m.
Fuel Injection Equipment Subcom.—Mon., 2:00 p.m.
Insert Valve Seats Subcom.—Tues., 2:30 p.m.

Fuels & Lubricants Tech. Com.—Tues., 2:00 p.m.

Ignition Research Com.—Wed., 1:30 p.m.
Aircraft Gas Turbine, Ram-Jet & Rocket Engine Ignition Subcom.—Tues., 9:00 a.m.
Aircraft Piston Engine Ignition Subcom.—Tues., 2:00 p.m.
Ordnance & Industrial Ignition Subcom.—Wed., 9:00 a.m.

Iron & Steel Tech. Com.—Mon., 9:00 a.m.
Exec. Com.—Mon., 1:30 p.m.
Panel A—Steel Producers—Mon., 9:00 a.m.
Div. 7—Carbon Steels—Thurs., 1:30 p.m.

Lighting Com.—Wed., 9:00 a.m.

Nomenclature Materials Com.—Fri., 9:00 a.m.

Non-Metallic Materials Com.
Central Power System Fluid Subcom.—Thurs., 10:00 a.m.

Riding Comfort Research Com.—Thurs., 9:00 a.m.

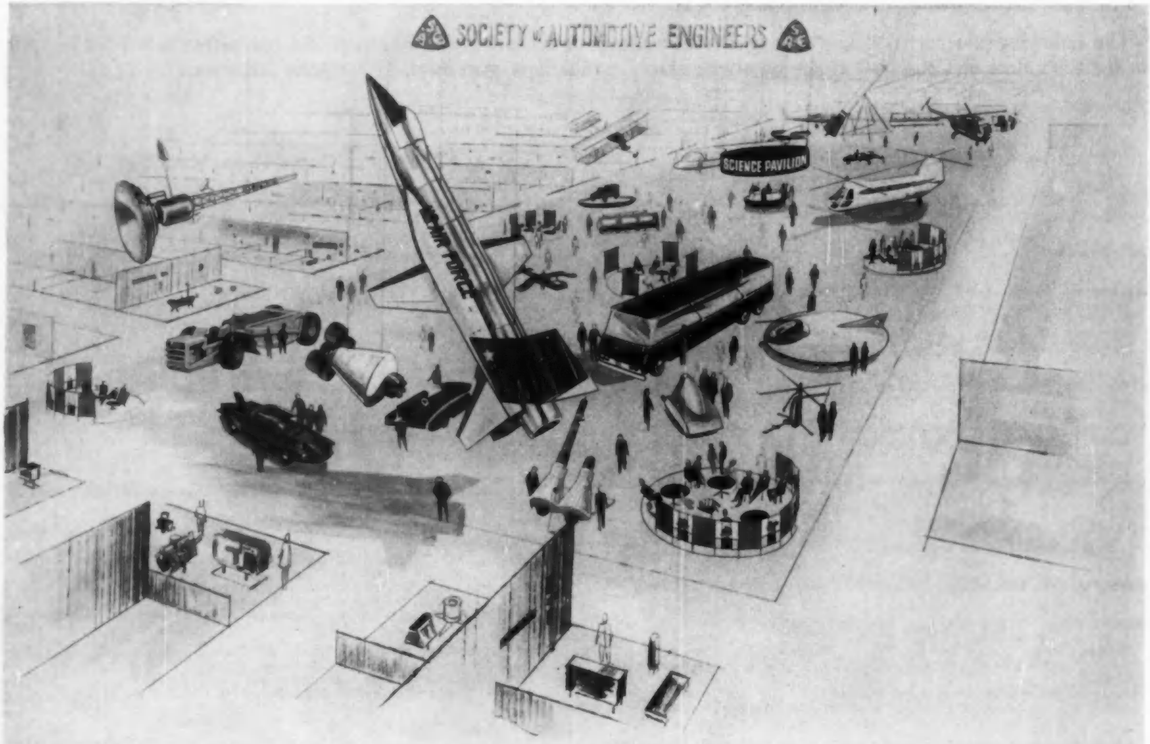
Tractor Tech. Com.—Thurs., 9:00 a.m.

Transmission Com.—Thurs., 12:00 noon (luncheon)
Controls Subcom.—Wed., 11:00 a.m.
Friction Subcom.—Tues., 9:00 a.m.
Terminology Subcom.Thurs., 9:00 a.m.

Tube, Pipe, Hose & Lubrication Fittings Com.—Wed., 9:00 a.m.
Hydraulic Hose & Hose Fittings Subcom.—Tues., 2:00 p.m.

Truck & Bus Technical Com.
T&M and T&B Kingpin Subcom.—Tues., 9:00 a.m.

Complete details regarding additional committee meetings may be obtained at the Information Desk in the Registration Area.



The Science Pavilion

The Science pavilion at the heart of the Exposition will dramatize the theme "Science Applied to Automotive Engineering." Educational, non-commercial exhibits in a 20,000 sq. ft. area will show:

- new nonferrous materials and new ways to strengthen ferrous materials
- the widening spectrum of propulsion power sources (including fuel cells, the Stirling-cycle engine, solar energy devices, and such)
- new types of vehicles to give man added mobility over the earth's surface and through space
- application of SAE standards in automotive equipment

. . . plus scores of other exhibits showing how engineers are making prompt use of discoveries in chemistry, physics, psychology, mathematics, sociology, and other fields of science.

When you tour the Exposition take time to see the Science Pavilion, too. You'll find stimulation for your imagination — and a place to sit down, meet your friends, and get answers to your questions about SAE services at the SAE Information Center.

To get to the Science Pavilion walk straight down the center aisle (aisle 1100 on the floor plan shown on p. 32) from Cobo Hall's main entrance.

Visit the International Exposition of Automotive Engineering

Over 200 companies will display their products to the entire automotive industry — ground and flight — at Cobo Hall. The following is a partial list of exhibitors and products to appear at the Exposition (see floor plan on p. 32 for booth locations).

AC SPARK PLUG DIV., GENERAL MOTORS CORP. 1711
Automotive instruments and protective and maintenance parts for automotive engines.

AEROQUIP CORP. 1122
Flexible hose lines, self-sealing couplings, tie-down and load control equipment.

AL-FIN CORP. and WHITEFIELD LABORATORIES 1826
Bimetalic components, coated turbine veins and blades.

ALLEGHENY LUDLUM STEEL CORP. 1606, 1507
Stainless steels and stainless clad materials.

ALLEN AIRCRAFT PRODUCTS, INC. 1533
Portable anodizing machine, valves.

ALUMINUM CO. OF AMERICA 1107
An exhibition of aluminum's versatility and design potential in both decorative and functional automotive components.

AMERICAN BOSCH ARMA CORP., COMMERCIAL SALES DIV. 1717
Automotive electrical and diesel injection equipment, LP-gas carburetion, hydraulic cranking systems.

AMERICAN SEALANTS CO. 1516
Loctite sealant.

AMERICAN STEEL & WIRE DIV. OF U. S. STEEL CORP. 227
Alloy, carbon, high strength, stainless steels, vinyl coated steel sheets, tubular products and wire products.

AMERICAN ZINC INSTITUTE, INC. 224
Zinc die castings, zinc coatings for steel, zinc pigments for rubber, and rolled zinc for automotive industries.

ANCHOR COUPLING CO., INC. 1039, 1037
Flexible hydraulic hose assemblies.

ARMCO STEEL CORP., ARMCO DIV. 836
Special purpose automobile steels.

ASSOCIATED SPRING CORP. 1014
Precision mechanical springs, small stampings, wire forms, custom fasteners, assemblies, with emphasis on automotive applications.

AUTOMOTIVE INDUSTRIES 1307
Technical automotive publications.

AUTOMOTIVE RUBBER CO., INC. 738
Body chassis and electrical all rubber connectors, bellows. Rubber and plastisol to metal parts. Sealants.

AVON TUBE DIV., HIGBIE MANUFACTURING CO. 1816
Resistance welded and brazed steel tubing.

BARBOUR STOCKWELL INSTRUMENTS, DIV. OF CURTIS & MARBLE MACHINE CO 1329
Tachometers and instrument drives.

THE BENDIX CORPORATION 1813 thru 1835

Bendix Computer Div.
Digital computer and data processing systems.

Bendix Products Div., Aircraft Section
Gas turbine controls and fuel injection systems.

Bendix Products Div., Automotive Section
Power steering, brakes and power brakes and universal joints.

Bendix Radio Div.
Radios.

Bendix Support Equipment
Test equipment for power steering, power brakes, master cylinder and fuel controls.

Eclipse Machine Div.
Carburetors, electric fuel pumps and starter drives.

Lakeshore Div.
Power steering, and brake valves and cylinders, brake equalier.

Marshall Equipment Div.
Brake linings and brake parts, clutch facings.

Scintilla Div.
Magnetos, diesel fuel injection and manifold heaters.

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE CO. 1623
Air brake systems and air actuated devices.

BOLLING WHEEL & AXLE DIV., ANDERSON BOLLING MFG. CO. 1830
Wheel and axle assemblies

BORG-WARNER CORP. 1123 thru 1139, 1222 thru 1238

Borg and Beck Div.
Torque converters and clutches for automotive applications.

Marbon Chemical Div.
Cycolac plastics products for the automotive industry.

Long Mfg. Div.
Torque converters and Brake-Mate retarder for trucks, buses, and off-the-road equipment.

Morse Chain Co.
Hy-Vo chain display, automotive timing chains and power transmission parts.

Pesco Products Div.
Static invertors, cooling packages and cryogenic pumps for the missile field.

Rockford Clutch Div.
Clutches for various automotive applications.

Spring Div.
One-way clutch, Brummer Seal Div. automotive products.

Warner Automotive Div.
Spin-resistant differential and pre-loaded differential.

Wooster Div.
Hydraulic systems for trucks, buses and automobiles.

York Div.
Compressors for automotive air-conditioning applications.

ROBERT BOSCH CORP. 1316
Automotive electric and diesel engine equipment.

BOSTROM CORP. 1134
Torsion bar suspension truck seat and permathane (polyether urethane foam).

THE BUDD CO. 833, 837, 1032, 1036
Tools and dies, pattern equipment, wheels, hubs and drums, welding controls, testing equipment, ground support equip., etc.

CALIFORNIA OIL CO. 1615
Chevron starting fluid and appliances.

CANADAIR LTD. 2020

CAPITOL REPRODUCTIONS INC. 2014
Precision reproductions of engineering data.

CHELSEA PRODUCTS, INC. 1132
Power take-offs and split shaft assemblies.

CHICAGO RAWHIDE MANUFACTURING CO. 1616
Shaft seals, end face seals, etc., and molded synthetic rubber and related components.

CITIES SERVICE OIL CO. 1706, 1710
Oils and lubricants.

CLARK EQUIPMENT CO. 832
Colorful display featuring various types of transmissions, torque converters, axles and suspension systems.

CLAYTON MANUFACTURING CO. 217
Dynamometers and dynamometer absorption units.

CLEVELAND GRAPHITE BRONZE DIV., OF CLEVITE CORP. 1138
Sleeve bearings, bushings, washers, seals, nickel cadmium battery plaques and cooper foil.

CONTINENTAL MOTORS CORP. 1506
Internal combustion engines—automotive, marine and aviation.

CORNELL AERONAUTICAL LABORATORY, INC. 1730, 1732, 1734, 1736
Scientific developments.

CRUCIBLE STEEL CO. OF AMERICA 2108
New permanent magnetmotors for automotive uses, stainless alloys, and a 1910 steamer, together with a prototype of the car of the future.

CYRIL BATH CO. 1920
Bath tension controlled blank holder.

DANA CORP. 1544
Transmissions, axles, propeller shafts, auxiliary transmissions, limited slip differentials.

DANIELSON MFG. CO., SUBSIDIARY OF: NICHOLSON FILE CO. 1233
Molded and extruded plastics.

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DAYTON INDUSTRIAL PRODUCTS CO., AUTOMOTIVE OEM DEPT., DIV. OF DAYCO CORP. 123
V-belts, radiator hose, and urethane products.

DELAVAN MANUFACTURING CO. 1312
Fuel injection nozzles for gas turbines, afterburners and ramjets.

DETROIT ALUMINUM AND BRASS CORP. 1644, 1646
Bearings and bushings.

DETROIT AUTOMOTIVE PRODUCTS CORP. 1630
Differentials.

DETROIT CONTROL DIV., AMERICAN STANDARD 1744
Engine thermostats.

DOEHLER-JARVIS, DIV. OF NATIONAL LEAD CO. 815
Die castings, anodized formed aluminum parts.

DOW CORNING CORP. 2021
Silicone parts and products for aircraft and automotive applications.

DOW METAL PRODUCTS CO., CHEMICAL, PLASTICS AND MAGNESIUM DIVISIONS 2009-2013, 2015
Chemical, plastics and magnesium for the automotive industries and light metal products.

E. I. DU PONT DE NEMOURS & CO., (INC.)
Elastomer Chemicals Dept. 1007
Neoprene, "Hypalon," "Viton," "Adiprene" and Urethane Foam.

POLYCHEMICALS DEPT. 1015
"Zytel," "Lucite," "Delrin," "Alathon" and "Teflon."

DUALOC DRIVE, INC. 1836
Power dividing differentials and axles.

DUCTILE IRON DIV., THE INTERNATIONAL NICKEL CO. 216
Ductile iron auto, components used in passenger cars and trucks, including crankshaft, thin-walled engine blocks, heads, differential carriers and brake drums with information on the engineering properties of the material.

DYNAMIC FILTERS, INC. 726
Static and dynamic filtration equipment.

THE ECONOMY ENGINE CO. 1729
Bench test demonstration of Kaehni continuous ignition system

ELASTIC STOP NUT CORP. OF AMERICA 607
Elastic stop nut for heavy automotive transmission and bearing retainer applications, rollpin spring pins, quick release fastener for cover and panel applications.

THE ELECTRIC AUTOLITE CO. 1115
Spark plugs, batteries, wire, die castings, electrical parts, plastics, instruments and ceramics.

ELECTRIC HOSE & RUBBER CO. 1611
Rubber and plastic hose.

ENFAB, INC. 1416
Molded compressable fiberglass for insulation, cushioning, gasketing and non-metallic springs.

ENJAY CHEMICAL CO. 822, 828
Butyl rubber, Escon polyprepylene, Burton resins and oil and fuel additives.

EVANS PRODUCTS CO. 1227
Truck and bus heaters and ventilating systems.

FAWICK BRAKE DIV., FAWICK CORP. 1207
Brakes — hydraulic and air, actuating equipment, controls, lines and hoses.

FILTERS, INC. 1416
Fiberglass water separator filters for jet fuel and diesel engines.

FORD INDUSTRIAL ENGINE DEPT. 1639
Ford industrial engines, 134 to 534 cubic inches, gasoline and diesel.

FORD DIVISION 1629, 1631, 1633

FORD TRACTOR & IMPLEMENT DIV. 1635-1637
A display of transmissions, hydraulic cylinders and pumps, gear boxes, angle drives and other components for OEM use.

FRAM CORP., MANUFACTURERS SALES DIV. 1239
Oil, fuel, air and water filters.

GARLOCK, INC. 1317
Packings, gaskets, seals, molded & extruded rubber & plastic products.

THE GARRETT CORP. 1423
Turbochargers for diesel engines and gas turbine equipment.

GARRISON MFG. CO., INC. 728
Hydraulic power steering components, power clutch assists, cylinders, valves.

GAYLORD PRODUCTS INC., GAYLORD CONTROL DIV. 627
Motion defector display.

GENERAL DYNAMICS CORP., LIQUID CARBONIC DIV. 522
Environmental low-temperature testing, truck cooling with carbon dioxide, maintenance and manufacturing gases.

GENERAL MOTORS, CORP., DELCO PRODUCTS 1328
Auto shock absorbers, air suspension leveling valves, engine support rods.

GENERAL MOTORS CORP., DELCO REMY 1022, 823
Closed circuit TV tour of Delco Remy manufacturing facilities in Anderson, Indiana and Delco Battery operation in Muncie, Ind.

GENERAL MOTORS CORP., DETROIT DIESEL ENGINE DIV. 506
Diesel engines.

GENERAL RADIATOR, INC. 1326
Heat exchangers, oil coolers, radiators.

GILLETT & EATON, INC. 1607
Cast iron and aluminum pistons and castings.

HARTFORD MACHINE SCREW CO. DIV. OF STANDARD SCREW CO. 1917
Fuel injection pumps and accessories, fuel oil filter.

HARVEY ALUMINUM 1523
Aluminum and titanium mill products.

HELI-COIL CORP. 1638
Screw thread and screw-lock inserts and related taps, tools and gages.

HERCULES MOTORS CORP. 1814
Engines.

Exposition hours will be:

Monday and Wednesday . 10:00 a.m. to 6:00 p.m.
Tuesday and Thursday . . . 11:00 a.m. to 9:00 p.m.
Friday . . . . 9:00 a.m. to 3:00 p.m.

HEYER INDUSTRIES, INC. 1029
Oscillograph engine analysis equipment.

HOLLEY CARBURETOR CO. 638
Carburetors for automotive and aircraft industries, fuel metering devices, accessories for aircraft industry, electro mechanical products.

HUMBLE OIL & REFINING CO. 2121
Tires, batteries, accessories, petroleum products for service station use.

ILLINOIS TOOL WORKS — SHAKEPROOF, FASTEX AND SPIROID DIV. 1311
Shakeproof fastenings, metal stampings and plastic moldings, spiroid and related gears.

THE INTERNATIONAL NICKEL CO., INC. 415, 417, 646, 744
Stainless steels, chrominum, nickel plated steels and cupro-nickel alloys in various finishes, colors, and patterns; and animated slo chart of the nickel plating process particularly as it relates to automotive components such as bumpers, grilles, etc.; newly developed nickel alloy steels for gears, shafts, etc.; applications of nickel-containing castings in automotive fields.

INTERNATIONAL BUSINESS MACHINES CORP. 414, 416
1620 data processing system.

JACK & HEINTZ, INC. 1513, 1515
Variable speed, constant speed systems for aircraft and a new AC electrical transmission system for ground vehicles, quick connect couplings, static frequency chargers.

JAM HANDY ORGANIZATION 1716
Technical training information.

L. E. JONES, INC. 510
Valves, valve seat inserts, precision castings.

JOHNSON BRONZE CO. 1406
Sleeve bearings, bronze bars, powder metallurgy products.

KAISER ALUMINUM & CHEMICAL SALES, INC. 1338
Aluminum used in '61 autos including engines, wheels, trim, etc.

KELSEY-HAYES CO. 1126, 1128, 1130
Wheels — passenger — truck — both disc & cast, hubs & drums, passenger & truck cast iron & aluminum brakes — hydraulic & electric.

KISTLER INSTRUMENT CORP. 1622
Spark plug-pressure gage combinations, surface ignition indicators, engine pressure indicators, vibration indicators.

KOLENE CORP. 1539
Tufftride 12th Bath Nitriding Process, Kolene Salt Bath, casting, cleaning and stainless steel descaling.

KYSOR HEATER CO. 730
Automatic radiator shutters — truck cab air conditioners.

LADISH CO. 228
Large closed impression die drop forgings of seamless rolled rings manufactured by Ladish as custom component parts for jet aircraft, missiles, and rockets, diesel and automotive applications.

LAKE SHORE INC. 1427
Dynamometer bases, stands, and jacks.

LAPEER MANUFACTURING CO. 1422
Toggle action clamping devices (manually and air operated; standard and heavy duty).

LEAR, INC. 1407
Electric retarder.

THE LEECE NEVILLE CO. 1714
Electrical equipment.

LIPE-ROLLWAY CORP. 1739
Heavy duty clutches.

LINK-BELT CO. 1331
Timing chain and sprockets.

LISLE CORP. 1136
Chip detectors and magnetic plugs.

LORD MANUFACTURING CO. 1027
Vibration/shock/noise control unit mountings and complete systems.

MACHINERY MAGAZINE 644
Engineering publications.

MARINE & INDUSTRIAL ENGINE DIV., CHRYSLER CORP. 1822
Internal combustion engines.

MAXWELL DYNAMOMETER CO. 144
Chassis and engine dynamometers.

McLOUTH STEEL CORP. 1538, 1536, 1439, 1437
Stainless and carbon steels — their role in transportation of the future. Ground and monorail vehicle concept portrayed in full scale.

MESSIER 1429
Hydraulics, disc brake, valves, servo mechanisms.

METAL POWDER INDUSTRIES FEDERATION 1215
Powder metallurgy products.

METALWORKING NEWS 1033
Business newspaper.

MIDLAND-ROSS CORP., OWOSSO DIV. 2109
Air and vacuum brake equipment. Bus door and power shovel air control equipment.

MINNESOTA MINING & MANUFACTURING CO. 639
High strength structural adhesive for joining metal and reinforced plastics.

MISCO PRECISION CASTING CO., DIV. HOWE SOUND CO. 1617
Precision investment castings.

MITCHELL SPECIALTY DIV., NOVO INDUSTRIAL CORP. 1410
Metering systems.

MOLDED FIBER GLASS BODY CO. 1909
Custom molded fiber glass automotive and truck cabs parts.

MONARCH TOOL & MACHINERY CO. 1916
Truck mirrors.

MONROE AUTO EQUIPMENT CO. 1844
Shock absorbers, stabilizer bars, power steering and seats.

MUSKEGON PISTON RING CO. 1828
Piston rings, rotating shaft seals and small precision castings.

NATIONAL LOCK CO. 215
Screws and bolts, and other hardware components.

NATIONAL TUBE DIV. OF UNITED STATES STEEL CORP. 227
Alloy, carbon, high strength stainless steels, vinyl coated steel sheets, tubular products and wire products.

GEORGE L. NANKERVIS CO. 1522
Test equipment.

NEW DEPARTURE DIV., GENERAL MOTORS CORP. 1417
Ball bearings as applied to automotive, aircraft, and instruments.

W. H. NICHOLS CO. 1229
Pumps: lube, scavenge and low pressure hydraulic.

NYLOK CORP. 629, 631

OWENS-CORNING FIBERGLAS CORP. 722, 623
Fiberglas automotive insulation, reinforced plastic application for automotive production, automotive headliners.

PACKARD-ELECTRIC DIV., GENERAL MOTORS CORP. 1330
Automotive assembles, batteries, cables, ignition cables, multiple connector bodies, fuse blocks, terminals and other component parts for the automotive field.

PERFEX CORP. 1746
Heat transfer products.

PHILADELPHIA STEEL AND WIRE CORPORATION 2113
Helical spring lock washers, standard and special purpose — close tolerance cold rolled strip steel — special rolled shapes in steel wire of steel strips.

PLAN HOLD CORP. 611
Vertical & roll filing equipment for blueprints, maps, charts.

PRECISION MECANIQUE LADINAL 1427
Diesel injection pumps.

PRESSTITE DIV., AMERICAN-MARIETTA CO. 1914
Automotive and aircraft sealing and sound dampening compounds.

PUROLATOR PRODUCTS, INC. 716
Oil, air and fuel filters.

PYLES INDUSTRIES INC. 1428

QUALITY ALUMINUM CASTING CO. 1726
Aluminum castings for truck engines (both gasoline and diesel), tractor, aircraft, government vehicles, transportation and others.

RADIATION, INC., DEFENSE PROD. DIV. 1612
Portable data acquisition system.

REPUBLIC STEEL 807
Stainless steel — flat rolled, carbon steel sheets; hot rolled and cold rolled carbon steel bars, steel tubing, etc.

REYNOLDS METAL CO. 1006
Automotive trim wheels, bumpers, engines, transmissions and other functional parts made of aluminum, also a special exhibit on finishes.

RINSHED-MASON CO. 113
Color styling of industrial paints.

ROBERTSHAW-FULTON CONTROLS CO., FULTON SYLPHON DIV. 1537
Engine thermostats.

ROCKWELL-STANDARD CORP. 1432 thru 1438, 1333 thru 1339
Axles, brakes, bumpers, filters, forgings, grilles, seats, springs, stampings and universal joints.

ROLLER REINFORCED PLASTICS 1915
Custom-molded fiberglass reinforced plastic parts.

ROSAN, INC. 1738
Fasteners including Slimsert Insert, press-nuts, and locked in studs.

ROSS GEAR AND TOOL CO., INC. 1810
Steering gears and related parts.

RUSSELL, BURDSALL & WARD BOLT & NUT CO. 222
Cold headed products, molded plastics, and powdered metal parts.

SAE JOURNAL 1832
Editorial and advertising information.

THE SATULLO CO. 1035
Test equipment.

SCOTT PAPER CO., FOAM DIV. 1511
Scott Filter Foam for use as air filters.

SEALED POWER CORP. 737
Piston rings, pistons, cylinder sleeves, and machine to manufacturer expander spacers.

SHARON STEEL CORP. 1231
Steel products.

SHELL OIL CO. 1723, 1727
A new ash-free, multi-grade motor oil.

R. H. SHEPPARD CO., INC. 1336
Power steering gears.

SHWAYDER BROTHERS, INC. 1614
Stampings made from vinyl metal laminates.

SIMMONDS PRECISION 734
Fuel injection systems, aircraft and missile instrumentation, mechanical products.

. . . continued on next page

. . . continued from preceding page . . .

S K F INDUSTRIES, INC. 1323
Pillow blocks, ball and roller bearings.

SNYDER TANK CORP. 1237
Fuel tanks.

SOUTHWEST PRODUCTS CO. 1031
"Monoball Dyflon (R)" bearings, mechanical push pull controls, air duct joints.

SPENCER MANUFACTURING CO. 1610
Torsion suspension, forging and axle shafts.

SPRAGUE DEVICES, INC. 2018
Air operated windshield wiper motors and small parts cleaner.

SPRAY PRODUCTS CORP. 1715
Spray starting fluid, Instantstart applicator, Nuts Off, Diesel Pep & Fire Extinguisher.

S. STERLING CO. 1626
Instruments.

STRATOFLEX, INC. 1722
Detachable and reusable hose fittings and hose assemblies, permanent attached hose assemblies, self sealing couplings and quick disconnect couplings for aircraft and industrial applications.

THOMPSON RAMO WOOLDRIDGE, INC. 1908, 1912
Engine and chassis components and systems.

THE TIMKEN ROLLER BEARING CO. 806
Tapered roller bearings.

THE TORRINGTON CO. 1838
Anti-friction bearings.

UNION CARBIDE CONSUMER PRODUCTS CO. 729, 733
Antifreeze and Long Life Coolant.

UNION CARBIDE PLASTICS CO. 723
All automotive applications using Union Carbide Plastics Company's materials.

UNISON-ACTION SEAT DIV., AMERICAN METAL PRODUCTS CO. 2008
Special feature truck and bus seats, automotive seats, aircraft engine components.

UNITED SHOE MACHINERY CORP. 1728

UNITED SPECIALTIES DIV. OF NOVO INDUSTRIAL CORP. 1410
Engine air cleaners and accessories.

UNITED STATES STEEL CORP. 227
Alloy, carbon, high strength stainless steels, vinyl coated steel sheets, tubular products and wire products.

UNIVERSAL CYCLOPS STEEL CO. 707
Stainless steel strip, stainless steel bar and wire, tool and die steels, high temperature metals, speciality steels.

WALKER MFG. CO. & DELUXE PRODUCTS CORP. 1322, 1223
Exhaust systems, filters, automatic lubricator.

WAUKESHA MOTOR CO. 1023
Internal combustion engines.

THE WEATHERHEAD CO., FORT WAYNE DIV. 1306
Air conditioning valves, receivers and driers, drain & shut off cocks, window vent assemblies, dash controls, heater controls, hydraulic brake lines, brake fittings, air brake hose, hose ends & fittings, experimental lines, brass & Steel tube fittings, hose & reusable ends, gas & oil lines, and power steering lines.

WEBB FORGING CO. 1235
Drop forgings.

WEST BEND ALUMINUM CO. 1627
Small gasoline engines.

WHITEHEAD STAMPING CO. 544
Metal stampings.

WYMAN-GORDON CO. 706, 710
Hammer and press closed die forgings.

ZOLLNER CORP. 2100
Pistons.

Special Student Programs

A special program has been prepared for engineering school students, high school and junior high school students. Be sure your engineering-minded sons and daughters attend. Come with them if you can, accompanying them through the displays, treat them to dinner, join them at technical sessions. Adopt one or more for the evening if yours can't come. All students welcome — with or without adults.

STUDENT ENGINEERS NIGHT
FATHERS and SONS NIGHT

Tuesday, January 10 4:30 to 8:00 p.m.

Both Groups

4:30 p.m. Tour Exposition and Science Pavilion

5:45 p.m. Dinner — Dutch Treat at Cobo Hall Cafeteria

Engineering School Students — Room 3038

6:45 p.m. Technical Session . . . 3rd Floor
Sponsored by SAE Student Activities Committee

Chairman: **E. P. White,** Chairman, Student Activities Committee, SAE Sections Board

EUGENE J. MANGANIELLO
Associate Director, Lewis Research Center
National Aeronautics and Space Administration
advising on

"Trends in Technology and How to Keep Up with Them"

Ways to keep pace with technological changes in the foreseeable future . . . and beyond.

* * *

High School and Junior High School Students — Room 3037

6:45 p.m. Father and Son Program . . . 3rd Floor
Sponsored by the SAE Detroit Section

Chairman: **Philip H. Pretz,** Director, Testing Operations Office, Ford Motor Co.

A. SCOTT CROSSFIELD
Chief Test Pilot and Design Engineer
Los Angeles Division
North American Aviation, Inc.
discussing the

"X-15 Flight Test Program"

Exciting story of test flights by the man who first piloted this remarkable aircraft.

* * *

Note: Students are invited to attend the Rotary Combustion Session starting at 8:00 p.m. See evening session on p. 30.

SAE Honors Its Overseas Guests

At the International Luncheon, SAE will pay special respects to engineering friends from other lands. Representatives from 10 or more countries will be honored.

* * *

INTERNATIONAL LUNCHEON

Tuesday, January 10 **12:00 Noon** **Main Banquet Hall**

Presiding — **J. N. BAUMAN**
President, White Motor Co.

Greetings — **1960 SAE President**
HARRY E. CHESEBROUGH

International Economic Development — The Part Transportation Plays In It

PAUL G. HOFFMAN
Formerly Studebaker's President and Board Chairman, Now Managing Director, United Nations Special Fund

Up-to-the-minute facts about transportation needs and practices, affecting economic growth of underdeveloped countries, will be dramatically presented. Mr. Hoffman's on-the-spot observations, extending into the far corners of the world, equip him authoritatively to tell us what is at stake and how we are meeting the challenge.

* * *

TICKETS — $5.00 — will be on sale at the SAE Registration Area, and should be purchased by 10:00 a.m. to assure accommodation.

Attend the SAE Annual Dinner

The traditional SAE Annual Dinner will be held in the main banquet hall of Cobo Hall starting at 6:30 p.m. on Wednesday, January 11. SAE's President for 1961, Andrew A. Kucher, will take over the Society's reins formally. John F. Gordon, president of General Motors Corp., will be the principal speaker.

SAE Annual Dinner

Wednesday, January 11 **6:30 p.m.** **Main Banquet Hall**

Enjoy a delicious meal and stimulating "speaking program". . . and the opportunity to broaden your acquaintance among the thousands of industrial leaders and engineers who will be present.

Greetings from SAE Detroit Section Chairman . . .

Max Moss Roensch
Assistant Chief Engineer, Chevrolet Motor Division, GMC

Presiding as toastmaster, 1960 SAE President . . .

Harry E. Chesebrough
General Manager, Plymouth Division, Chrysler Corp.

Welcome from incoming 1961 SAE President . . .

Andrew A. Kucher
Vice-President, Engineering & Research, Ford Motor Co.

Principal Speaker . . .

JOHN F. GORDON
President, GMC

TICKETS — $10.00 each

Plant Tours

Three outstanding plant tours have been arranged. Each tour is limited to 80 people; arrangements must be made through the Plant Tour Desk in the Registration Area at Cobo Hall on arrival at the Congress. There will be a nominal charge for bus transportation and for luncheon included with Tours 2 and 3.

Tour 1 — **Monday, January 9**

Visit to Plymouth Assembly Plant, Chrysler Corp.
Visitors will see complete body assembly line from floor pan to fenders as well as rustproofing process.

12:45 p.m. — Buses leave Cobo Hall main entrance
3:30 p.m. — Arrive back at Cobo Hall

Tour 2 — **Wednesday, January 11**

Visit to General Motors Technical Center
Visitors will tour the following buildings — Engineering Staff, Research Laboratories, Manufacturing Development, and Styling — and have lunch at the GM central restaurant dining room before returning to Cobo Hall in time for afternoon technical sessions.

9:00 a.m. — Buses leave Cobo Hall main entrance
1:15 p.m. — Arrive back at Cobo Hall

Tour 3 — **Thursday, January 12**

Visit to Ford Motor Co.
Visitors will tour the Scientific Laboratories, the hurricane road Ford wind tunnel and Dearborn test track, and have lunch in the Ford Body Engineering cafeteria.

9:30 a.m. — Buses leave Cobo Hall main entrance
1:15 p.m. — Arrive back at Cobo Hall

Other plans are in the mill, but on a more informal basis where the individual makes his own arrangements.

Other points of interest that may be visited in the Detroit area are university engineering facilities, foundries, transmission plants, engine and body assembly lines, fuel labs, and proving grounds.

Eating Facilities at Cobo Hall

The coffee shop, which is located on the ground floor of Cobo Hall directly beneath the cafeteria area (see floor plan on p. 29), can serve 200 people at a time. It will be open at all hours throughout the meeting.

The Cafeteria can feed 1,500 people at one sitting. It is located on the third floor of Cobo Hall (see floor plan on p. 29).

Message Center

Your office or associates can leave messages for you at Cobo Hall by calling Woodward 2-5870 in Detroit. Operators will take and post all messages received. When you register, ask for the location of the bulletin board. There will be no paging system and operators cannot attempt to locate individuals in the Exposition area or numerous meeting rooms.

Thanks go to these men . . .

. . . who planned the Congress and Exposition and to the many others who have contributed their time and efforts.

H. F. BARR, chairman, Engineering Activity Board (right) and R. H. ISBRANDT, chairman, Exposition Advisory Committee (left).

Engineering Activity Board

H. F. BARR, Chairman, D. M. Adams, O. A. Brouer, R. E. Cross, J. T. Dyment, W. Paul Eddy, F. W. Fink, W. W. Henning, R. H. Isbrandt, A. L. Klein, C. R. Lewis, E. J. Manganiello, P. S. Myers, C. F. Nixon, Karl Pfeiffer, V. G. Raviolo, F. A. Robbins, Randall Roman, K. W. Stalker, T. L. Swansen, J. E. Taylor, S. J. Tompkins, A. O. Willey, W. W. Withee.

Operations Committee

P. C. Ackerman, Chairman; L. E. Fleuelling, Chairman Attendance Promotion Subcommittee; C. C. Dybvig, Chairman Dinner Subcommittee; R. E. Johnson, Chairman Overseas Luncheon Subcommittee; O. K. Kelley, Chairman Plant Tours Subcommittee; Sam Petok, Chairman Publicity Subcommittee; A. L. Haynes, Chairman Science Pavilion Subcommittee; H. L. Brownback, Advisor to the President on Foreign Guests.

Exposition Advisory Committee

R. H. Isbrandt, Chairman, P. C. Ackerman, C. A. Chayne, D. B. Hammond, E. J. Hardig, A. A. Kucher.

Activity Committees (which planned the technical program for the Congress)

Aerospacecraft, F. H. Sharp, Chairman; *Aerospace Powerplant,* R. R. Higginbotham, Chairman; *Air Transport,* H. D. Hoekstra, Chairman; *Body,* D. C. Perkins, Chairman; *Fuels and Lubricants,* Gilbert Way, Chairman; *Nuclear Energy,* R. W. Middlewood, Chairman; *Passenger Car,* T. H. Thomas, Chairman; *Powerplant,* Gregory Flynn, Jr., Chairman; *Computer,* D. E. Hart, Chairman; *Engineering Materials,* J. H. Dunn, Chairman; *Farm, Construction and Industrial Machinery,* W. F. Shurts, Chairman; *Production,* C. W. Ohly, Chairman; *Science-Engineering,* Michael Ference, Jr., Chairman; *Transportation and Maintenance,* F. W. Petring, Chairman; *Truck and Bus,* R. R. Noble, Chairman; *and The International Information Committee,* T. B. Rendel, Chairman.

Participating Foreign Societies

The Institution of Automotive & Aeronautical Engineers (Australia), Automobil-technischer Verein (Austria), Societe des Ingenieurs de l'Automobile-Belgique (Belgium), Canadian Aeronautical Institute (Canada), The Institution of Mechanical Engineers — Automobile Division (England), The Royal Aeronautical Society (England), Suomen Teknillinen Seura (Finland), Association Francaise des Ingenieurs et Techniciens de l'Aeronautique (France), Societe des Ingenieurs de l'Automobile — France (France), Verein Deutscher Ingenieure — Fachgruppe Fahzeugtechnik (Germany), Wissenschaftliche Gessellschaft Fur Luftfahrt E. V. (Germany), Koninklijk Instituut Van Ingenieurs — Automobile Section (Holland), Nederlandse Vereniging Voor Luchtvaarttechniek (Holland), Association of Engineers and Architects in Israel (Israel), Associazione Italiana di Aerotechnica (Italy), Associazione Tecnica Automobile (Italy), Japanese Society of Aeronautic Engineers and Space Sciences (Japan), Society of Automotice Engineers of Japan, Inc. (Japan), Foreningen For Skeppsbyggnadskonst Och Flygteknik (Sweden), Mekanik, Svenska Teknologforeningen (Sweden), Schweizerische Vereinigung Fur Flugwissenschaften (Switzerland).

chips

from SAE meetings, members, and committees

SEAT BELTS REDUCED INJURIES 60%, in a series of matched-pair accidents, in which the only difference was the wearing of belts. Identical-accident studies also showed that moderate-to-fatal injuries were suffered five times less frequently when occupants were retained within cars by belts, and fatal injuries were increased eightfold when occupants were ejected.

RESONANCE induced by the walls of silo-type missile launching installations has provided Aero-Space Committee G-5 on Shock and Vibration with a new enigma, reports G-5 Chairman C. T. Molloy. Reason: A missile can be structurally damaged by noise feedback during launching.

SUCTION AND BLOWING-TYPE boundary layer control systems for providing short take-off and landing capabilities for cargo transports have been studied, and comparison shows the blowing system to be the more practical of the two. Although the suction system required about 50% less hp, the blowing system was found to be more feasible.

The blowing system is easier to manufacture, less liable to aerodynamic interference of joints, gaps, and protrusions, and far less susceptible to surface dirt, and the resulting maintenance problem.

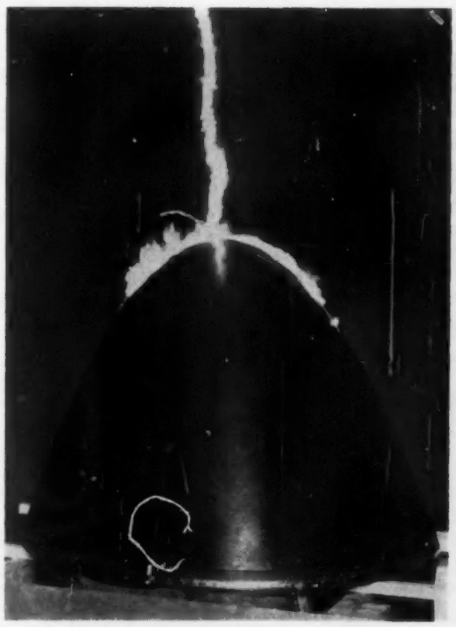
Beside these advantages, the blowing system can produce much greater lift when there is additional airflow, beyond that required to prevent separation. Since there is a reserve capacity designed into the system, in case of failure of one of the air supply engines, this additional airflow is normally available.

IN 1859, GASTON PLANTÉ wrote, "The secondary electromotive force obtained with lead plates in water, acidulated with sulfuric acid, was greater and persisted longer than that of other combinations." A hundred years of battery development work — on which has been built a giant industry — has failed to upset that statement.

TO HELP ELIMINATE INCLUSIONS some large producers of aluminum ingot are straining the metal through glass mesh cloth.

PERCEIVED JET NOISE level allowed by the New York Port Authority is 112 db maximum in the take-off flight path. It is found that the high thrust JT4A-3 engines can more readily conform to this requirement than can the comparitively low thrust JT3C-6 engines, even when the JT3C-6

1,500,000 V! A high-voltage charge is split and absorbed when it hits the nose radome of the Lockheed JetStar during lightning protection tests. The plane's nose section was pressurized to simulate flight at heights eight miles above the earth, and then hit with a charge of 1½ million volts. Four foil strips cemented in place before anti-erosion coating is applied and grounded to the structure completely absorb the static discharge.



chips

from SAE meetings, members, and committees

. . . continued

has a 35,000 lb weight advantage. This is due to better climb characteristics rather than quieter engines.

TOTAL ECONOMIC LOSSES FROM HIGHWAY ACCIDENTS are probably equivalent to a 12½¢ tax on every gallon of gasoline consumed, according to research undertaken by the Bureau of Public Roads in cooperation with a number of State highway and motor vehicle departments. Put another way: our collective pocketbooks are drained of 5 to 7 billion dollars annually — no one knows exactly how much.

AERODYNAMIC HEATING in high speed aircraft makes the wing, from a heat transfer standpoint, the most inefficient fuel stowage space in an aircraft. This is so because the geomtry of most wings results in the highest aerodynamically heated area per pound of fuel. To offset this, it is usual practice to empty the fuel contained in the wings early in the mission if the center of gravity of the aircraft allows.

BULB REPLACEMENTS in motor truck lamps average 73 per vehicle per year, according to a field survey by an automotive lamp manufacturer.

266,200 PREPRINTS of technical papers were produced by the General Publication Department of SAE during 1960. Included in this total were 13,500 preprints of SAE Sections' papers.

MORE JET FUEL IS BEING USED than the oil companies expected. The higher consumption is due partly to runway delays and traffic control problems encountered by transports, unavailability of optimum cruising altitudes at times, and need for more pilot-training flying than was anticipated.

DIRECT ENERGY CONVERSION devices will probably not obsolete dynamic conversion systems as a source for space vehicle power. This is especially true for the case of manned vehicles where the requirement of energy in various forms is a necessity nullifying the simplicity advantage of the direct device.

ANY MECHANICAL PROCEDURE for cleaning or smoothing the surface will at least superficially disturb it and render it unfit for stress measurements by X-rays — unless the disturbed layer is removed. For example, gently abrading a hard steel surface with emery cloth by hand induced more than 50,000 psi in compression. Removing soot with a pencil eraser, which contains a fine abrasive, has created stress in excess of 10,000 psi in compression.

ALUMINUM used per passenger car in the United States passed the 50 lb mark between 1958 and 1959. In France, consumption per car was 66 lb in 1958; and in Italy, 77 lb.

THE AMOUNT OF WATER NEEDED TO PRODUCE FLAME EXTINCTION is about 10 times that required to eliminate smoke. That's what tests on aircraft gas turbine combustors featuring stoichiometric primary zones have shown. This is important during water injection . . . risk of flame extinction is slight.

A FAVORITE PLACARD on the desks of men concerned with designing lubricants, says Monsanto's **E. L. Will**, might well be:

"You don't have to be crazy to work here, but it helps!" Reason? Consider the following requirements for gear lubricants, and the limitations simultaneously imposed:

Requirement	*Limitation*
1. Lubricate spur, worm, and spiral bevel gears, under loads from 0 to 18,000 lb per in. face.	Use a minimum number of lubricants, preferably one.
2. Must react with metals.	Must not corrode metals.
3. Must be stable at temperatures to 300 F.	Must react chemically with metals very rapidly.
4. Must form high strength load carrying films.	Must from low shear strength films.
5. Chemical reactivity.	Long life.
6. High performance.	Low cost.

Electric car with fuel cell power

. . . is feasible technically right now. But economic feasibility is a long way off, current studies indicate.

Based on paper by

M. Eisenberg

Missiles & Space Div., Lockheed Aircraft Corp.

AN ELECTRIC AUTOMOBILE driven by fuel cell power is technically feasible right now.

But until fuel cells operating efficiently with conventional, inexpensive fuels are available, such an automobile isn't likely to be economically feasible.

The hydrogen-oxygen fuel cell, for example, is currently the most advanced technologically. Researchers know more about it than about any other types of fuel cell. It would be the most likely fuel cell to be used if an electric automobile powered by fuel cells were to be attempted by researchers at the present time.

But hydrogen — especially electrolytic hydrogen — is too expensive a fuel to make the car economically attractive. Under the best circumstances of quantity and processes, the current cost of hydrogen, it is estimated, might be brought from a $1 to $2 per thousand cu ft to 30¢ to 40¢ per thousand cu ft. . . . which would bring the cost of gaseous hydrogen in a fuel cell operating at 50 to 60% efficiency to something like 1.0 to 1.6¢ per kilowatt-hour. If the hydrogen were liquified this cost would go to 2.0 to 4.5¢ per kilowatt-hour. . . . And the lower of these costs is substantially higher than those offered by present conventional fuels.

Then too, hydrogen in the form of a gas would have to be transported in high pressure containers, almost certain to be frowned upon by transportation authorities. Besides, the high ratio of tank weight to the weight of the fuel would be a serious drawback to the vehicle's performance.

And, while liquified hydrogen can be handled with less tank weight, it is bulky . . . and requires a constant boil-off, which is incompatible with the intermittent use of a vehicle.

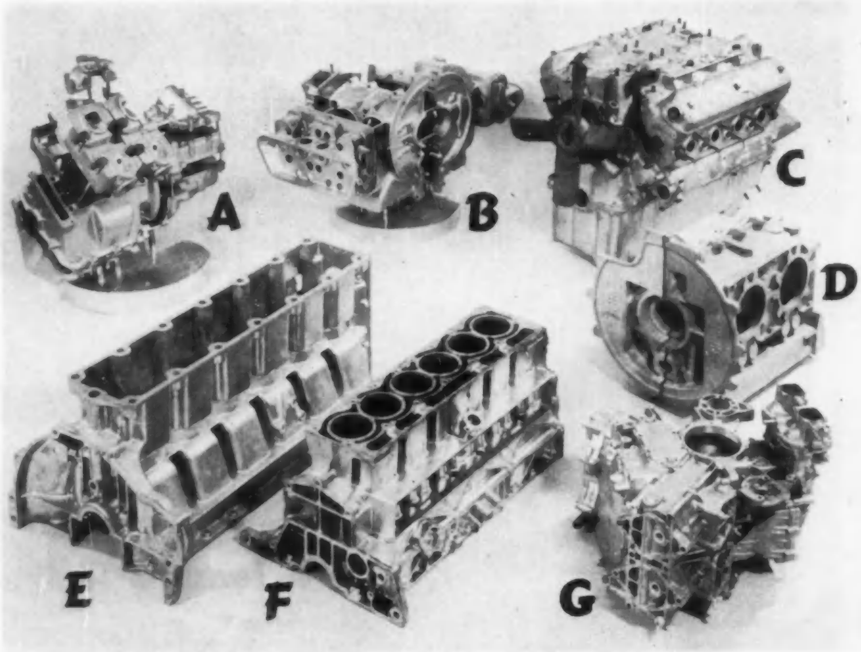
These and other reasons suggest that, except for limited uses and special applications, the hydrogen-oxygen fuel cell is not likely to become the basis of the fuel-cell-operated automobile.

So, it's no wonder that researchers all over the world are trying hard to find a way to develop fuel cells which will operate efficiently with conventional, inexpensive fuels. Nor is it surprising that most research groups are keeping their findings to themselves at this point.

The indications are, however, that current investigations are mainly in the area of fundamental investigations. In this stage, the basic phenomena and fundamental problems are common, regardless of the type of fuel consumed in the fuel cell.

The principles for engineering design of fuel cells remain still to be developed. This appears to be an important area on which the future development of fuel cells for transportation and automotive purposes may depend.

To Order Paper No. 212B . . .
from which material for this article was drawn, see p. 6.



Die-cast 50-60-lb parts may give lead to U. S. in lb-per-car of aluminum

Based on paper by **A. F. Bauer**
Doehler Jarvis Division, National Lead Co.

Based on material drawn from an

SAE Twin City Section Paper

EUROPEAN CAR DESIGNERS are currently showing great interest in aluminum die castings for engine blocks and cylinder heads of water-cooled engines. The rapid development in the United States of large engine blocks produced by aluminum die casting has them worried.

So far, the Europeans have used more aluminum per car than have the United States producers. But the availability of die-cast aluminum engine blocks in this country bids fair to reverse that situation.

Only a few expensive European sport cars like German BMW, the Italian Alfa Romeo, or luxury cars like the British Rolls-Royce have introduced aluminum in large parts — because they have had to produce such parts in expensive sand casting for their water-cooled engines. Most European water-cooled cars — like Renault's Dauphine, Simca's Aronde and the English and German Fords — still have gray-iron engine blocks and heads . . . because they have found aluminum permanent-mold castings too expensive for such parts; and because die castings large enough for such parts are not yet available in Europe. Light metals in European passenger cars have been used mainly by those producers using aircooled engines — like Porsche and Volkswagen.

The preference of aluminum for aircooled engines, of course, lies in its combination of light weight and high thermal conductivity. For these two advantages, the European industry has been willing to pay a premium for aluminum permanent-mold parts.

This trend is illustrated by examination of the typical engines and engine blocks shown in Fig 1.

U. S. die-casts 50–60 lb units

But United States' production lead in ability to produce large 50–60-lb aluminum die castings bids fair to be the basis of our passing the Europeans in

Fig. 1 — Typical aluminum engines and blocks.

(a) German Lloyd Alexander LT600 engine, a 2-cyl aircooled, 25-hp, tilted design. All parts are aluminum except two gray-iron cylinder barrels. First produced as permanent-mold castings, the aluminum parts are now produced by die-casting.
(b) Porsche engine is a 4-cyl, opposed, aircooled powerplant, with vertically split crankcase and transmission housing. All castings are produced in aluminum by semipermanent-mold process.
(c) BMW 501/2 engine is a 140-hp, water-cooled V-8 with wet gray-iron sleeves. All parts are made in aluminum sand casting.
(d) Experimental sand-cast prototype of an opposed, 4-cyl aircooled engine.
(e) Kaiser engine block, produced in 1955 as an aluminum die casting. It was designed for wet gray-iron sleeves.
(f) Newer type in line 6-cyl engine block in aluminum die casting with dry sleeves cast in gray iron into the block.
(g) Outboard Marine Corp. 4-cyl engine block.

THE PRACTICABILITY of aluminum die castings as large as those required for engine blocks was forecast nearly four years ago by Author Bauer in SAE JOURNAL.

An article titled "Door Opens to 75-lb Aluminum Die Castings" in the January 1957 SAE JOURNAL brought out that:

> *"Successful development of a 43-lb, 6-cyl engine block as a one-piece die casting opens the door on large aluminum die castings for the automotive industry. . . . The previous limit of 20 lb maximum weight has been overcome by development of a die-casting machine capable of handling aluminum die castings up to 75 lb."*

One recent fruition of these then-new techniques is the 52-lb, die-cast aluminum cylinder block being used in the 1961 Rambler. A saving of 80 lb was made possible by the changeover to aluminum, according to American Motors' engineers.

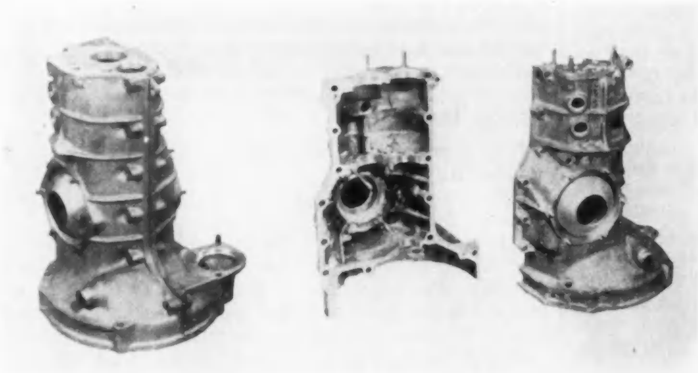


Fig. 2 — Volkswagen transmission case — which is produced as magnesium die casting on machines imported from United States.

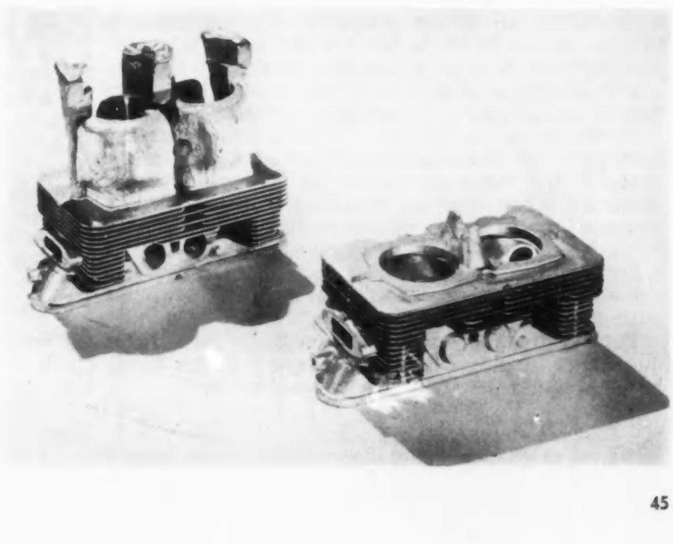


Fig. 3 — Porsche cylinder head shown as produced (left) in standard permanent-mold casting with heavy risers and (right) in the low-pressure casting method — in which metal is fed into the die by low air pressure instead of by gravity.

Die-cast . . . continued

the pounds per car of aluminum used in the years immediately ahead. U. S. has die-casting machines with locking pressures of 1600, 2000, and even 2500 tons, while most European die-casters do not have even a 1000-ton machine.

The Europeans are, however, working actively toward larger die-casting sizes. Triulzi, a large Italian producer of die-casting machines, for example, has completed a large portion of an order from Russia for four large 2500-ton locking-pressure, die-casting machines and four die-casting dies to produce the small 4-cyl engine block for the Russian Volga car. And four leading European makers of water-cooled engines have ordered experimental die castings from other machine producers.

Volkswagen has changed its crankcase housing and its transmission housing from magnesium permanent mold to magnesium die castings. Its transmission case (Fig. 2) is being produced on die-casting machines imported from the United States. The change from permanent mold castings, according to Volkswagen officials, had reduced manufacturing costs on this unit by 30%.

Citroen in France is still using an alumnum permanent mold casting for its large transaxle housing, but already has the unit's smaller covers in die casting.

United States trends

As "aluminum engines" continue to be introduced in the United States, two different trends have developed as regards the casting process by which the larger castings are made.

Some American companies have taken directly the giant step from gray-iron to aluminum die castings. Others are giving preference to aluminum semipermanent mold, which can replace gray-iron castings without too many changes in casting equipment. These companies feel that their existing gray-iron foundries can be converted to an aluminum permanent-mold foundry with less cost than to die casting . . . and that re-education of their foundry personnel is less difficult.

For its Corvair aircooled engine, Chevrolet chose the so-called low-pressure casting method, which is a modification of the standard permanent-mold process in that metal is fed into the die by a low air pressure of 5–15 psi, instead of by gravity.

The European Porsche cylinder head (Fig. 3) is shown as produced in standard permanent mold, with heavy risers, and in the low-pressure casting method. The reduction of large risers and heavy gates is the main advantage of the low-pressure casting method over the standard permanent-mold process. In the case of aircooled cylinder heads, with their intricate channels, these processes have a distinct advantage over die casting, because sand cores can be used where undercuts in the channels cannot be avoided.

For large water-cooled V-8 engines, some producers are making engine blocks and cylinder heads by the regular semipermanent-mold process.

To Order Paper No. S258 . . .
from which material for this article was drawn, see p. 6.

Design-stage

. . . brings five major

Based on paper by

Melvin A. Walck

Tractor and Implement Division, Ford Motor Co.

THEORETICAL structural analysis performed in the design stage is one of the proved methods that can be used to do a better total engineering job in the development of new agricultural equipment. It is effective in establishing realistic design loads, in achieving consistent strength in components, reducing weight and cost, cutting development time, and reducing the number of prototypes.

Design loads

If a component, implement, or tractor is to be structurally efficient it is mandatory to establish realistic design loads as a basis for design and subsequent testing. Design-stage structural analysis yields a complete set of design loads, listing external and internal loads for each condition potentially critical. Concurrence of the responsible design engineers is obtained and the load data are then made available to all designers associated with the project.

Many advantages accrue from this method. Among them are:

- Design engineering personnel should produce more satisfactory initial designs because they know critical conditions and loads.
- All components of the basic structure are more uniform in strength.
- Design load data can be modified or extrapolated for future design when considered with test results and service.
- The load data can be used as test loads for prototype testing, to expedite the design of modifications, to provide data for specifications required by government agencies and customers, and for evaluating strength of competitive designs.

Consistent strength

Subjecting a project to this type of analysis results in more uniform strength in the structural components of a machine and the strength is more consistent from one design to another. This is so because:

- Prior establishment of design loads permits

structural analysis

advantages to engineering farm equipment

analysis of each component for critical loading conditions.

- Margins of safety for all members in a structure can be held to a uniform level.
- Fatigue life can be calculated from the frequency and severity of loads anticipated during the projected service life of the design.
- Use of identical loading criteria by tractor designers and designers of attached equipment will bring designs of more nearly balanced strength.

Reduction of weight and cost

Structural analysis in the design stage will minimize weight and, to a lesser extent, cost. Weight and strength can be applied where needed, and weight can be removed where it isn't needed. Moreover, recommendations for alternate or simplified approaches to the strength problem often allow appreciable cost savings. An efficient design is more likely to be developed if analyses of various combinations of members, materials, sizes, and shapes are made in the design stage rather than after testing and completion of evaluation programs. Postponement encourages conservatism because most changes require further testing and evaluating which means more engineering time and cost.

Design-stage analysis can yield dividends in terms of greater strength margins at essentially no direct cost by bringing out opportunities for improving strength early in the program.

Cutting development time

Initial engineering calendar time and manpower requirements generally are not reduced by using structural analysis in the design stage. They may be slightly more. But the greater initial investment results in lower time and manpower requirements in the functional, strength, and endurance testing programs. The net, then, is a cut in the total development time.

Prototype reduction

When a prototype of a carefully engineered design meets all tests, there's little need to design and fabricate more prototypes. Design-stage structural analysis helps to get the initial design right to save time in sequential prototype construction. This statement can be confirmed by case histories.

Three design programs were given design-stage structural analysis. Two showed no significant structural deficiencies in the testing program and only minor differences existed between the first prototype and the production unit. The third design showed a deficiency in the analysis, but rather than revise the design immediately, a prototype was built and tested for strength. The laboratory test corroborated the analytical prediction and a different structural component was developed. The revised component was 54% stronger, weighed 21% less, and reduced cost by 27%.

During the same period, nine comparable design programs were put through with strength and field testing but without independent design-stage structural analysis. In Table 1, these nine designs are compared with the three which underwent the independent analysis to indicate the savings in time and money afforded by the analytical method.

To Order Paper No. 219A . . .
from which material for this article was drawn, see p. 6.

Table 1 — Comparative Data on Projects Conducted With and Without Independent Design-Stage Structural Analysis

	Design-Stage Analysis	No Independent Design-Stage Analysis
Number of Projects	3	9
Average Number Of Prototypes	2	2.45
Projects Requiring Significant Structural Modification		
Number	1[a]	6
Per Cent	33[a]	67

[a] Predicted.

designing with plastics

Foamed plastics catch Detroit's fancy

Versatility of cellular plastics opens door to automotive applications

Based on report by

G. A. Ilkka, S. L. Reegen, and P. Weiss

General Motors Research Laboratories

REINFORCED PLASTICS, their fabrication and use in ground vehicles, are described in the new SAE Technical Report TR-188. The report will help engineers with little or no materials experience select reinforced plastics for specific applications.

In TR-188 classifications based on method of fabrication and a product's end use are given along with a description of:

- **RESINS** (thermoset and thermoplastic) used in reinforced plastics.
- **REINFORCING MATERIALS** (organic and inorganic) commonly used.
- **FABRICATION METHODS**
  Pressure Molding at high pressure — 1500 to 3000 psi, medium pressure — 100 to 1500 psi, and low pressure — 0 to 100 psi.
  Injection Molding
- **PROCESSING METHODS** for moldings such as: flat sheet, matched metal, premix, hand lay-up and vacuum bag, and compression and injection of thermoplastics. Physical properties are given for these processing methods.

Reinforced Plastics for Ground Vehicle Applications was developed by the Reinforced Plastics Subcommittee of the Nonmetallic Materials Committee. The Subcommittee is headed by A. M. Hansen of Chrysler Corp.

FOAMED PLASTICS are a broad class of cellular materials available to the automotive designer. Differing only in physical form from the polymers from which they are derived, they offer the automotive engineer a wide range of properties from which to choose.

This article reviews the many diverse properties of commercially available foamed plastics and describes several automotive applications in which these materials have been successfully used to produce improved products.

Preparation and properties of plastic foams

Plastic foams have the same chemical composition as the polymers they are derived from, but differ in physical form. They are produced by expanding the plastic with a gaseous blowing agent. The properties of plastic foams (Table 1) can be varied widely depending on the raw materials and foaming techniques used.

Polyurethane foam is prepared by reacting polyols (polyesters or polyethers) with polyisocyanates (usually tolylene diisocyanate). The blowing agent can be either carbon dioxide gas, generated by the reaction of water on polyisocyanate, or a low-boiling inert liquid such as a fluorocarbon which accomplishes the blowing by evaporation. The rigidity of these foams can be controlled by the chemical composition of the polyester or polyether used in its production. These polyols can be of various compositions, molecular weights, and branching. In addition, the density can be varied from above 30 lb per cu ft to below 2 lb per cu ft.

Table 1 — Comparison of Properties of Plastic Foams

Material	Types	Density, lb per cu ft	Thermal Conductivity, Btu/ft²-hr-F-in.	Tensile Strength, psi	Compressive Strength, psi	Water Absorption, % at 50% relative humidity
Polyurethane	flexible	1.5–20.0	0.12–0.25	13–150	0.2–1.5 (at 25%)	0.5–4.0
	rigid	1.5–30.0		15–800	7–1500	
Polyvinyl Chloride	flexible	3.0–45.0	0.27	10–200		1.0–5.0
	rigid					
Cellulose Acetate	rigid	6.0– 8.0	0.31	150–180	125	1.9–2.5
Phenolic	rigid	0.3–25.0	0.18–0.28	4–200	1–1100	1.0–5.0
Polystyrene	rigid	1.0– 5.0	0.24–0.26	33–180	14–150	Nil
Polyethylene	semi-rigid	3.0		670		Nil
	rigid	15.0				Nil
Silicone	flexible	12.0–16.0	0.3	15		1.0
	rigid	3.5–18.0	0.3		100–325	1.0
Epoxy	rigid	4.0–40.0	0.25–0.30	100–1000	10–900	

The production of these foams has been accomplished by a prepolymer process which first necessitates reacting the polyol resin with an excess of the diisocyanate to produce an isocyanate-terminated resin. This is then reacted with the polyester or polyether (in the presence of catalysts and blowing agent) to produce the foam. The "one-shot" foam process, another method for preparing foams, eliminates the need for synthesizing the prepolymer, since the diisocyanate and polyol resin are reacted during the foaming process. It has the advantage of providing a foaming mixture with a lower viscosity and good flow characteristics, but makes it more difficult to control the foaming conditions. Foaming machines have been developed for use in both processes, with special mixing heads that deliver the exact amount of polyurethane required into the unit to be filled.

These foams have excellent strength-to-density ratios which has made them attractive for structural applications. Their elastic nature enables them to withstand vibration. The insulating properties of polyurethane foams have been enhanced with the advent of fluorocarbon blowing agents. With properly formulated rigid foams, the volatile solvent is entrapped in the foam cells. The presence of the fluorocarbon gas results in thermal conductivity (K) factors that are lower by a factor of 2.

Foamed vinyls are made from polyvinyl chloride (PVC) resins or copolymers. The open-cell flexible foams are produced by incorporating an inert gas, usually carbon dioxide, into a liquid PVC plastisol under pressure and releasing the mixture to the atmosphere. The resultant foam is then fused at elevated temperatures. Either molded or slab stock can be produced.

The plasticizer-resin ratio can be varied to change the resiliency of the foam at a given density. Changes in the foam density can be obtained by varying the temperature at which the gas and plastisol are mixed.

The foam exhibits outstanding aging and stress characteristics; it does not oxidize or harden and will not hydrolyze. It is not attacked by most inorganic acids, alkalies, oils, greases, aliphatic hydrocarbons, and alcohols. It can be formulated in white or in color, and will not fade or darken.

Closed-cell foams, both rigid and flexible, in the density range of 3 lb per cu ft to 10 lb per cu ft, are produced by a pressure-blowing process. In this method, a blowing agent is incorporated which decomposes at the fusion temperature, releasing nitrogen gas. Foamed sections produced are limited in size. Where large rigid sections are desired, atmospherically blown foam can be used.

Products from this technique have medium to high density (10 lb per cu ft to 45 lb per cu ft), and usually contain a large percentage of open cells. In this method, the plastisol and blowing agent are cast into an open mold and fused at 350–400 F while expanding at atmospheric pressure. The blowing agent-plastisol ratio is lower than in the pressure-blowing method. They can be made with excellent resistance to tearing, shock, and abrasion, and a sufficiently low K factor to make them attractive as insulating materials.

Cellular cellulose acetate is produced by the flash vaporization of a volatile solvent from molten cellulose acetate. It cannot be foamed in place but is an extruded product that is available in the form of boards and rods. It has excellent strength properties and thermal stability. It can be maintained at 350 F for long periods with no decomposition. Exposure to low temperatures causes little change in physical properties — values at − 70 F are 80% of those at room temperature. It exhibits a burning rate of 5 in. per min; and its low thermal conductivity points to its possible use in insulation. Excellent

plastics . . . continued

buoyancy characteristics are obtained, reaching a stabilization value of 52 lb per cu ft after five days immersion in water. Foamed cellulose acetate (CA) is available as a rigid, white foam with no odor or volatile components.

Polystyrene foam is available in expanded and expandable forms. The expanded form is obtained by foaming polystyrene resin up to 40 times in volume; it is produced as blocks and sheets. Expandable polystyrene can be obtained as beads that contain an expanding agent. When heated, they will expand to over 60 times their original volume —to densities as low as 1 lb per cu ft.

These foams are closed cell structures with excellent thermal insulating properties and dielectric characteristics. When combined with its low water absorption and low water vapor permeability, excellent buoyancy properties can be obtained with a buoyancy factor of 55 lb per cu ft. The water absorption, after 48 hr immersion under hydrostatic pressure equivalent to 10 ft of water, is less than 0.9% by volume. Self-extinguishing grades of polystyrene foam are commercially available that meet the requirements of A.S.T.M. test method D-653-44.

The thermal conductivity of expandable polystyrene foam varies with density to a minimum value of 0.24 at 2 lb per cu ft.

The foam can be successfully bonded to itself and to most other materials; techniques have been developed for the use of both drying and curing types of adhesives.

Fig. 1—Polyurethane foam in seat cushion construction of 1960 Corvair sedan front seat.

Fig. 2—Section of instrument panel cover showing polyurethane foam. The foam is deposited directly onto the inner surface of the vacuum formed plastic covering.

Phenolic foam is available commercially as two types. One is called a "reaction-type" foam that is produced by taking advantage of the heat of reaction of the phenolic resin to cause vaporization of the small amounts of water and solvent present in the mixture of resin, catalyst, and modifying agents. During the foaming process, the resin changes rapidly from a free-flowing liquid to an infusible cellular solid. The "premixed" or "syntactic" foam is produced by combining hollow phenolic spheres with a resin (phenolic, epoxy, or polyester).

The reaction-type phenolic foam is characterized by its low density and good heat resistance as well as nonsupport of combustion. A structure of 40–60% open cells is obtained that gives good thermal insulating properties and some acoustical insulating properties. It has its best insulating value (a K factor of 0.18 Btu/in.-ft^2-F-hr) at a density of 2 lb per cu ft.

Syntactic foam, by virtue of its spherical cell shape, has a very high strength-weight ratio, along with good insulating properties. It is handled as a putty-like mass that can be trowelled onto surfaces. It can also be molded to shape, forced into cavities, or pressed into sandwich-core structures.

Cellular polyethylene is produced by foaming polyethylene that has been mixed with a blowing agent. Extrusion techniques have been developed, using conventional extruders, that provide the foam in the form of rods or boards.

The foamed product retains many of the properties of polyethylene (chemical, moisture, abrasion resistance, flexibility, and toughness).

Because of its electrical properties, cellular polyethylene is used as a primary insulation material. In resistance to moisture permeation, it is almost equal to the solid resin of equal thickness. This combination of moisture resistance, good insulating qualities, and 50% weight reduction gives it many advantages over the solid polymer.

Foamed silicones are produced from a series of premixed powders which are composed of a solventless polysiloxane resin (with a melting point of 120–140 F, a blowing agent, catalyst, and fillers. The powder is melted and the decomposition of the blowing agent liberates sufficient nitrogen to expand the resin. Amine by-products are formed which catalyze the condensation and gelation of the resin. Room temperature cure foams are also available. They are formulated as two liquid components which are mixed and poured, producing an expansion up to 10 times. Hydrogen gas is liberated as the expansion agent, but the quantity is small and has not presented any hazards.

Silicone foams can resist continuous exposure to 600 F. Heat resistance plus a low K factor makes silicone foams attractive as high-temperature insulating materials. They also have excellent flame resistance, good electrical insulating properties, and a low order of water absorption.

Foamed epoxies can be obtained for foam-in-place applications or as preformed slabs and blocks. Free-flowing powders are available which contain all the necessary ingredients. Foaming and curing can be carried out by heating at 185–250 F. The product can be of low-to-high density, depending upon the formulation; the physical strength will be proportional to the density. Similar foamed epoxies may

about the authors . . .

Ilkka

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Prior to joining the GM Research Laboratories, Ilkka did research on cycleweld adhesives at Chrysler.

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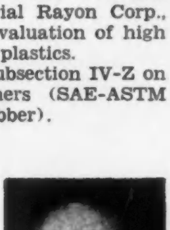
Reegen

DR. SIDNEY L. REEGEN, Supervisor in the Polymers Department at the General Motors Research Laboratories, is responsible for the synthesis of new polymers. He received the B.S. degree in Chemistry from the City College of New York, and the M.S. degree in Organic Chemistry and the Ph.D. in Polymer Chemistry from the Polytechnic Institute of Brooklyn. His graduate research was in the field of polyamides and polyesters.

Prior to joining the Research Laboratories of GM in 1958, Dr. Reegen had seven years industrial research experience, at North American Rayon Corp. and the Industrial Rayon Corp., devoted to the synthesis and evaluation of high polymers for use as fibers and plastics.

Dr. Reegen is chairman of Subsection IV-Z on Stress Relaxation of Elastomers (SAE-ASTM Committee on Automotive Rubber).



Weiss

DR. PHILIP WEISS, as head of the Polymers Department, General Motors Research Laboratories, is responsible for research and development in rubber, plastics, adhesives, surface coatings, and the synthesis of new polymers. He holds B.A., M.S. (physical chemistry), and Ph.D. (organic chemistry) degrees from New York University. Weiss has been a Teaching Fellow at New York University and a chemistry instructor at Cooper Union.

For the past 22 years, Dr. Weiss has been engaged in research and development of organic chemical intermediates, polymers, and copolymers. Prior to joining GM Research Laboratories, he was associated with the research departments of American Cyanamid and Colgate-Palmolive.

Weiss serves as a member of the SAE Nonmetallic Materials Committee and the Plastics Subcommittee of the Engineering Materials Activity Committee of SAE.

plastics . . . continued

be obtained by mixing of a two-part liquid composition.

Epoxy foam slabs have a fine, uniform structure and may be carved or machined to a good surface. Finishing coats may be applied easily. It has excellent dimensional stability when exposed to moderately elevated temperature and high humidity. At high temperatures, some epoxy foams will soften. They can then be formed into simple or complex curvatures.

Automotive applications

One of the most important automotive uses of plastic foams is in seat cushions (Fig. 1). The polyether type of flexible polyurethane foam was the engineering material of choice for the fabrication of the topper pad since this type of polymer structure offers improved resilience and desirable riding qualities.

Polyurethane foam has been able to compete on a cost basis with conventional materials since it offers the inherent property of a greater load bearing capacity for a given density. Greater toughness and tear resistance of polyurethane foams make it feasible to hog-ring or staple it directly to the seat frame, thus eliminating the cemented fabric reinforcing strips. Redesigning the seat to take full advantage of the desirable characteristics of the polyurethane foam, that is, fabrication of the foam cushion with its upholstery cover onto a molded plastic seat as an integral unit may result in an improved product at lower cost.

The instrument panel cover (Fig. 2) also uses a flexible type of polyurethane foam which is foamed directly onto the inner surface of a vacuum formed plastic covering. The foam used in this case is much

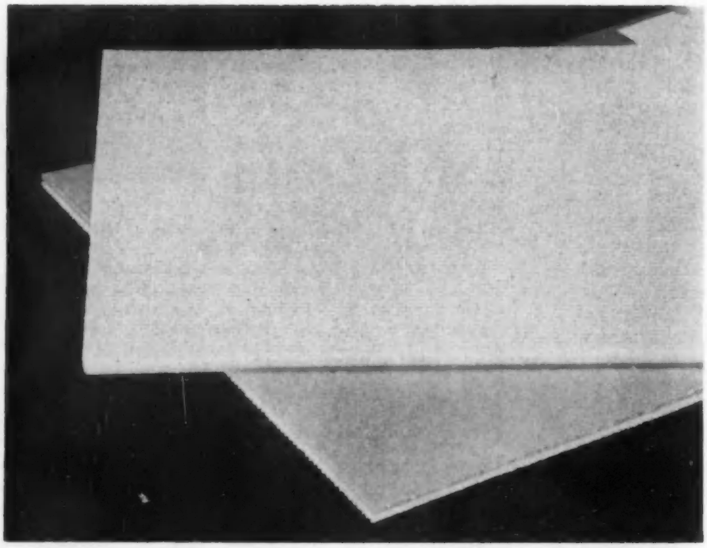


Fig. 3 — Polyurethane foam headliner material. Any desired color is incorporated into a chlorosulfonated polyethylene coating which is applied over the foam.

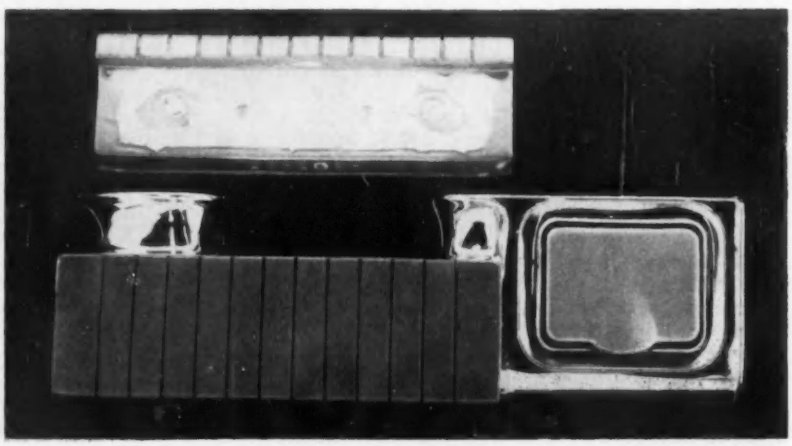


Fig. 4 — Arm rest with foamed-in-place polyurethane. The polyurethane is foamed against a slush molded vinyl plastic covering and a metal insert for attaching the arm rest to door.

less resilient than the type used for seating. Integrally foaming the polyurethane to the plastic covering results in a smooth and neat instrument panel cover.

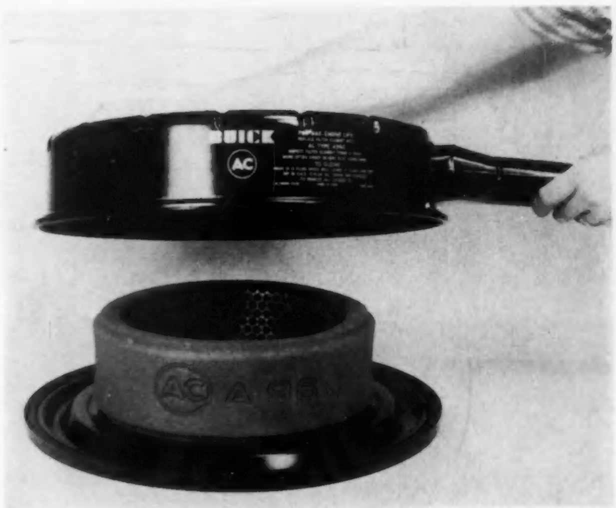
Polyurethane foam is being used on some 1960 models as a headliner (Fig. 3). The desired color is incorporated into a chlorosulfonated polyethylene coating which is applied over the foam.

Arm rests (Fig. 4) are produced to a limited extent from polyurethane foam. The polyurethane is foamed in place against a slush molded vinyl plastic covering and a metal insert for attaching the arm rest to the door. This results in an integral unit that is much simpler to fabricate than the conventional arm rest which requires building up foam rubber onto a molded base and covering with a fabric-backed vinyl plastic.

Polyurethane foam has also found its way into an application in the engine compartment of two 1960 models as the filter in carburetor air cleaners (Fig. 5). For this application, a flexible polyurethane foam is specially processed to give an open cell or skeletal structure with uniform porosity. The elastic foam is easily assembled over a metal mesh frame and is self-sealing at top and bottom. Since the polyurethane is oil resistant, the filter element can be impregnated with oil to increase filtering efficiency. The filter element can be easily washed and reoiled in the same manner as the previously used metal mesh type. Even with frequent cleanings, the foam filter is expected to have a long service life because of the excellent durability of the polyurethane. In comparison to conventional filter elements, the foam filter has greater filtering efficiency than the metal mesh type and costs less than the resin impregnated paper cartridge type.

Fig. 6 shows a schematic drawing of a tire soaper fixture which is used by one of the automobile manufacturers for applying soap solution to the tire beads to facilitate assembly to the rim. Fig. 7 shows

Fig. 5 — Filter element for carburetor air cleaner made from polyurethane foam. The foam is specially processed to give an open cell or skeletal structure with uniform porosity.



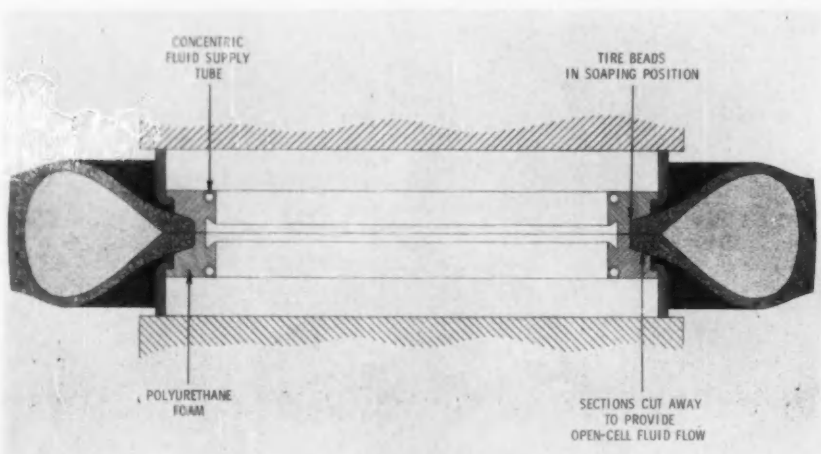


Fig. 6 — Polyurethane foam tire soaper fixture used by one automobile manufacturer for applying soap solution to tire beads to facilitate assembly to the rim.

plastics . . . continued

THIS IS THE LAST of a series of six articles written exclusively for SAE Journal on "Designing with Plastics for Automotive Applications."

PREVIOUS ARTICLES in the series were by:

- **J. H. CRATE** and **J. D. YOUNG** of du Pont on Designing with Plastics for Automotive Applications (August).
- **R. C. OGLESBY** of Rohm & Haas on Transparent Plastics (September).
- **J. H. VERSTEEG** of Union Carbide on Blow-Molding and Thermoforming Plastic Shapes (October).
- **A. J. CARTER** of Chrysler on Strength and Stiffness Properties of Plastics (November).
- **J. R. FORRESTER** of Ford on Plastics Aplications Involving Color and Texture (December).

ALL SIX ARTICLES are available as SP-184 at $1.50 to SAE members; at $3.00 to nonmembers. To order, see p. 6.

a photograph of the fixture with a tire assembled in it. A ring of flexible urethane foam is used to apply the soap solution — thus utilizing the sponge-like characteristics of the polyurethane. The molded skin of the foam is cut away in the areas of the tire beads so that the soap solution which is fed through the concentric supply lines is confined to the bead area. This method of applying soap solution to the tire has proven to be faster and cleaner than the method used previously in which the tire was revolved and soap solution was sprayed on. The foam is sufficiently durable and resistant to the soap solution so that 70,000–100,000 tires can be soaped before the foam requires replacing.

Future possibilities for foam

A foamed-in-place fire wall would serve the dual function of heat and sound insulation. A flexible vinyl or polyurethane foam carpet underlay integrally attached would provide a cushioning effect with less tendency for wrinkling. Semirigid foam applied to the underside of hoods and trunk lids may result in eliminating the existing reinforced structure.

Foam padded sun visors should complement the luxurious effect obtained with foam used in arm rests, seating, and instrument panel cover.

Foamed plastics appear promising in bus and truck applications. A closed-cell rigid or semirigid foam sandwich construction of the bus roof and wall panels would provide structural strength and rigidity as well as sound and thermal insulation. A similar construction would appear to be ideally suited for various types of refrigerated trucks.

Due to the versatility of physical properties one can obtain with foamed plastics, it is reasonable to predict an increase in automotive applications. Of major importance in the creation of new and improved products is the necessity of the design and materials engineer to discard the conventional methods of fabrication and direct his efforts to create a new concept in manufacture by taking full advantage of the desirable features of foamed plastics.

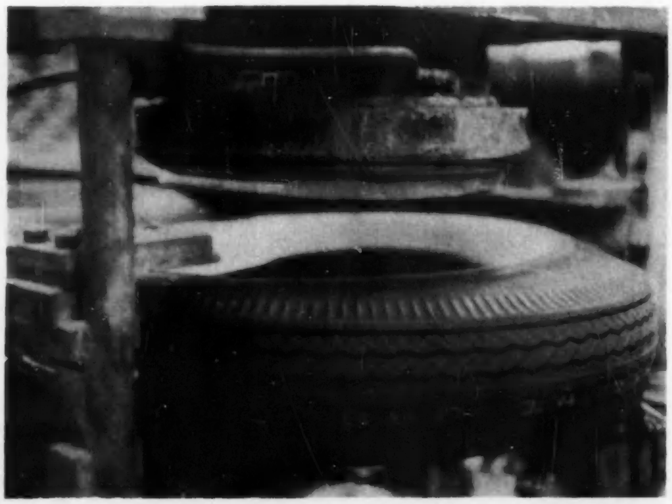


Fig. 7 — Tire soaper fixture showing polyurethane foam tire soaper and tire in place.

Maintaining life on space missions

. . . involves supplying necessities, disposing of undesirables, letting crew know true conditions through visual displays.

Based on paper by

R. B. Wilson

Convair (Astronautics) Division, General Dynamics Corp.

THERE are nine requirements for supporting the life of two to four men in an earth-orbiting space vehicle on a mission lasting one to three weeks. These requirements are:

- Oxygen.
- Carbon dioxide removal.
- Inert gas reserve for cabin pressure.
- Temperature control.
- Water vapor removal.
- Water.
- Waste disposal.
- Food.
- Safeguard against radiation.

Oxygen supply

It is generally agreed that 2 lb of oxygen per day at 1 *g* is ample for the average 175-lb crew member. Consumption in a weightless state is unknown; it is probably lower if there is no anxiety. A reserve should be provided, although oxygen stores can be prolonged by decreasing activity, as is shown in Table 1.

Maintenance of a high level of efficiency requires a gas mixture containing at least 116.5 mm oxygen partial pressure as in air (79% N_2, 21% O_2) at 564 mm total pressure, to a value approaching at least 150 mm oxygen partial pressure as we remove the inert constituent and so reduce the total pressure of the gas mixture. A greater value of oxygen partial pressure will do no harm, provided it does not exceed about 400 mm, in fact it's better if a buildup of CO_2 content is anticipated. A maximum safe value of oxygen partial pressure of 400 mm is suggested for indefinite confinement. Pure oxygen is

Table 1 — Man's Oxygen Consumption and Heat Output at 1 *g*

Activity	Oxygen Consumption, lb/24 hr, at Body Weights		Heat Output, Btu/24 hr, at Body Weights	
	150 lb	200 lb	150 lb	200 lb
Rest (in Bed)	0.75	1.0	5,000	6,500
Rest (Standing)	1.02	1.36	6,800	9,000
Desk Work	1.44	1.92	9,600	12,800
Strolling	2.4	3.2	16,000	21,000

Maintaining life on space missions

. . . continued

undesirable in a space cabin because of fire hazard. Practical maximum total cabin pressure should be 760 mm, although it can be less if other design considerations encourage it.

Carbon dioxide removal

Man yields carbon dioxide proportionately to oxygen intake, as shown in Table 2. A yield of 2.2 lb per day is the amount for an average 175-lb crew member but, as with oxygen, the output can be reduced by decreasing activity and there should be a reserve absorption capability provided.

For exposure to long periods of time, medical authorities recommend keeping the inspired carbon dioxide partial pressure below 4 mm (normal sea-level partial pressure for CO_2 is 0.23 mm).

Water-vapor removal

The moisture given off by the human body is a function of size, activity, and ambient temperature. The weights of perspiration and respiration vapor given off by the average sized man at normal temperatures are given in Table 3. Note that reducing activity has less effect on water vapor output than it has on carbon dioxide yield.

Human comfort is probably highest at relative humidities of 50% in ambient temperatures of 65–75 F. The body gives off moisture even when at rest, so the problem is one of moisture removal to prevent an excessive accumulation of humidity. All gases within the body cavities, including lung air, are at 100% water-vapor saturated condition, in other words possess a vapor partial pressure of 47 mm. If the air is allowed to attain this much vapor partial pressure, physiological functions will in time become seriously disturbed, and unconsciousness leading to death will result because there are no body mechanisms left for dissipation of heat. The minimum permissible vapor pressure without performance decrement is about 25 mm and the minimum is zero, limited only by the discomfort of the severe drying effect.

Table 2 — Man's Carbon Dioxide Yield at 1 *g*

Activity	Carbon Dioxide Yield, lb/24 hr, at Body Weights 150 lb	200 lb
Rest (in Bed)	0.9	1.2
Res (Standing)	1.15	1.53
Desk Work	1.62	2.18
Strolling	3.0	4.0

Water intake and output

Assuming that man is provided water at a normal consumption level and is not forced to draw on his bodily reserves, his average daily intake and output of water at 1 *g* is as shown in Table 4. These average sub-amounts are subject to wide variation, although with good health and exercise at a low level the total should approximate 5.6 lb.

Opinions differ as to how much water is needed per man-day for washing, food preparation, and personal hygiene. Estimates run all the way from 2 to 60 lb. This suggests the need for research. For missions lasting several man-days it would seem possible to do with less personal washing, to use prepared and packaged food requiring no washing, and disposable food containers. Disposable clothing might save on the weight of water needed for laundering.

Waste disposal

Foreign matter and odorous, noxious, and toxic gases must be kept at a low level of concentration in the space cabin atmosphere. Carbon monoxide, hydrogen, methane, paracresol, and other fuel gases should be held to no more than 10 ppm, while other odorous gases such as hydrogen sulfide, indole, skatole, ammonia, and methylmercaptan should be held to less than 50 ppm. All are given off in human excreta or perspiration or food cooking, but in such small quantities that it would take months to reach toxic proportions. Nevertheless, control of contaminants is necessary to maintain personal efficiency, safety, and morale.

Food supply

Experiments prove the necessity of providing a wide variety of attractively packaged foods to maintain crew morale and efficiency. Variety helps to break the monotony of the routine. Each crewman (depending on his physical size) will require 1.6 to 2.0 lb of dehydrated food per day.

For the next 10-year period at least, atmosphere control, waste disposal, water and food supply will not be provided reliably by a closed ecological system based on algae chlorella. Consequently, the necessary systems are open or semi-open ecological ones requiring resupply at intervals. A proposed cabin atmosphere system is shown as a block diagram in Fig. 1.

Radiation

The biological effects of extra-atmospheric radiation are still unknown. They can only be inferred by extrapolation from known radiation effects. If earth satellite vehicles are orbited at altitudes below the Van Allen belt, and below geomagnetic lati-

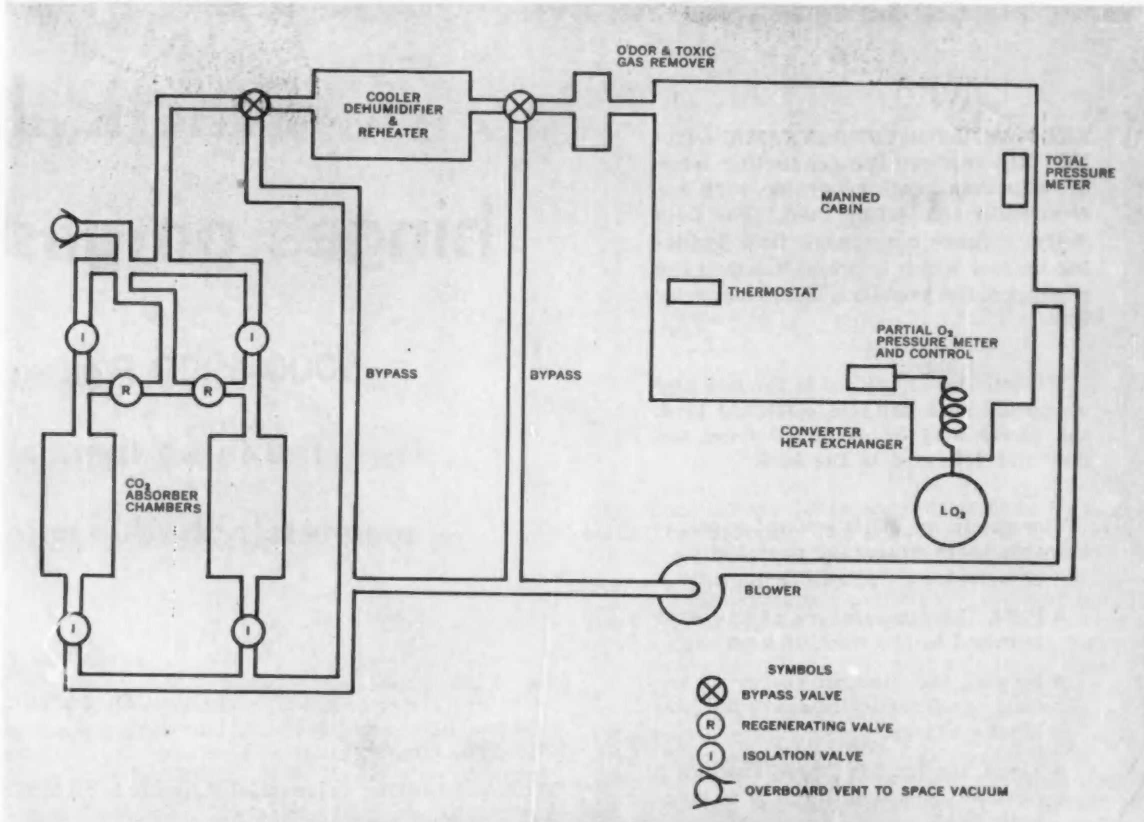


Fig. 1 — **Proposed atmospheric control system** for space vehicle cabin.

tudes 45 deg, the permissible time for man in space, without shielding of any sort other than that provided by the vehicle structure, may be quite long. Heavy nuclei, high-energy cosmic radiation is most to be feared. It cannot be stopped by shielding of practical configuration and will cause secondary biologically troublesome radiation upon incidence with the vehicle structure. Fortunately, its normal hit frequency appears to be low.

Psychological considerations

Crew members need reassurance that their life-support system is functioning properly. And if it is not, they need to know it so that undesirable trends can be corrected. For this reason, the transient and cumulative condition of the equipment must be displayed for their information. Display coupled with the opportunity to make manual corrective adjustments enhances the reliability of the system. Still greater reliability can be had with a man along to monitor the system and overcome maintenance problems if they arise.

To Order Paper No. 244B . . .
from which material for this article was drawn, see p. 6.

Table 3 — Man's Respiration and Perspiration at 1 *g*

Activity	Water Vapor Output, lb/24 hr
Rest (in Bed)	1.5–2.2
Rest (Standing)	2.2
Desk Work	2.2
Walking	Up to 5.5

Table 4 — Human Daily Water Balance

	Intake, lb		Output, lb
Drink	2.7	Urine	3.1
Water in Food	2.2	Stool	0.3
Metabolic Food Conversion	0.7	Respiration and Perspiration	2.2
Total	5.6	Total	5.6

THE MAGNETOHYDRODYNAMIC GENERATOR replaces the conducting wires of a conventional generator with an electrically conducting fluid. The fluid moves through a magnetic field, inducing an emf which is proportional to the product of the velocity and the magnetic flux.

If electrodes are placed in the flow and connected to a suitable electrical load, the power may be extracted from the flow and delivered to the load.

The gas in an MHD generator passes through three stages of operation:

- First, the temperature of the fluid is raised to the working level.
- Second, the internal energy of the fluid is adiabatically converted into kinetic energy.
- Third, the fluid is passed through a channel in which there is a magnetic field.

The source of the magnetic field may be a permanent magnet, an electromagnet, or an air core magnet, depending on the situation. Two sides of the channel are insulated from the fluid flow and act as the pole pieces of the magnet; the other two sides are the electrodes.

As the conducting fluid passes through the magnetic field, an emf is induced and electrons will flow to the positive electrode. The electrodes in turn are connected to the electrical load.

The configuration of the channel need not be straight; spiral or even radial arrangements are possible. The generator may be used to generate either a-c or d-c power.

Practical hinges on gas

5000-6000 F gases the three thermal magnetohydrodynamic

Based on paper by

G. W. Sutton

General Electric Co.

THE only working fluids suitable for use in an MHD generator are gases. Practical considerations require that these gases operate under the following conditions:

1. The gas must be sufficiently conducting so that the pressure drop in the channel through which the gas passes is caused by the Lorentz force rather than by friction.

2. The temperature of the gas must not exceed the thermal limits of the material used to confine the gas or serve as heat exchangers.

3. The temperature of the gas must be high enough so that the thermal efficiency of the MHD generator exceeds that of the conventional supercritical steam powerplant.

By coincidence, these three thermal requirements are met within the same temperature range — namely, 5000–6000 F. If this weren't the case, the design of an MHD generator would command much less interest from a practical standpoint.

The requirement that the internal energy of the fluid in the MHD generator be adiabatically converted into kinetic flow energy implies that the only suitable working fluids are gases. The use of gases, however, presents certain difficulties since gases normally are not good conductors. There are two reasons for this: gases are difficult to ionize, and the mean-free-path for electrons is usually very small in gases.

The lowest ionization potential of an element is 3.87 ev for cesium. This means that temperatures over 4000 F are needed to ionize a sufficient number

MHD generator temperature

needed to meet requirements of a practical electrical power generator

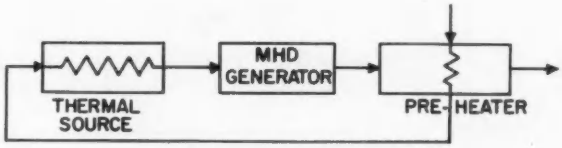


Fig. 1 — Preheat cycle for magnetohydrodynamic generator.

of electrons. 5000 F, however, has been found to be an even more desirable minimum temperature.

The mean-free-path for electrons in easily ionized gases is much smaller than for other gases. In addition, the electrical conductivity does not increase linearly with the electron density, for as the number of positive ions increases, the mean-free-path decreases rapidly. The net result is that the conductivity of a pure gas increases with the 1.5 power of temperature when the electrons are scattered mainly by ions. An upper limit of conductivity of 100–1000 mhos per meter is reached at about 5000 F.

To overcome the difficulties arising from these disparate properties, a mixture of gases has been suggested for closed cycles. A small fraction of an easily ionized gas would be mixed with a gas of small electron scattering cross-section. The low partial pressure of the ionizable gas will cause a larger percentage of it to ionize than if it alone were used; and the other gas allows the mean-free-path for electrons to be larger. Thus, a mixture of two gases allows the better properties of both to be utilized. As yet, the proper combination of gases which will successfully accomplish this has not been discovered.

High thermal efficiency a problem

The desire to obtain high thermal efficiency in the MHD generator presents a problem. Thermal efficiency is related to the difference between the high and low temperatures of the working fluid. The low thermal efficiency of about 35% in the steam powerplant results from having to use steam at far lower temperatures (usually 1100–100 F) than the combustion temperature of 2500–3000 F. To utilize higher temperatures in the steam powerplant would require special materials (due to the higher pressures) thus increasing capital costs.

The working fluid in the MHD generator must start from a high temperature if it is to be electrically conducting. The gas cannot be permitted to cool to any appreciable degree since its conductivity is strongly dependent on temperature. At best, the temperature can only be reduced about 1000 F. Thus exhaust gas temperatures will be high. Two possibilities exist for the use of the exhaust: it can be used to drive a gas turbine or steam powerplant, or it can be used to preheat the working fluid before it passes into the high-temperature heat exchanger (Fig. 1).

The high-temperature range, 5000–6000 F, in which the MHD generator operates, presents a severe materials problem. This may be relieved by cooling the walls although such cooling is necessarily limited. The electrodes may not be so cold as to permit the electrons to recombine with the ions before they reach the electrodes and the cathode must be sufficiently hot to emit electrons in the required amounts. For tungsten and graphite these temperatures are about 5000 F although lower temperatures may be possible for thoria and lanthanum boride. Cooling is desirable in the two insulated sides (the pole pieces) since it will reduce current leakage in the insulators. Of course, the cooling may not be so large that the bulk temperature is reduced more than a few per cent.

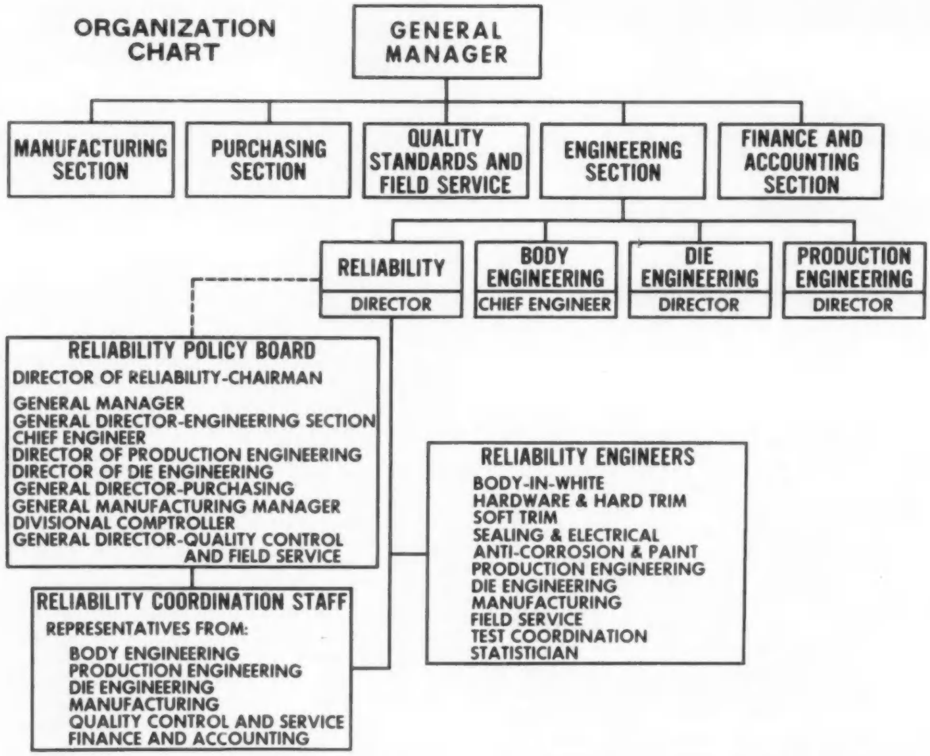
Unfortunately, the low pressure and high temperatures of the exhaust gas present shortcomings in connection with its use as input to a gas turbine.

Although this article has concerned itself with thermal ionization of the working fluid, other methods of ionization may be feasible using lower temperatures. Working temperatures below 5000 F and considerably lower exhaust temperatures would permit improved efficiency without the necessity of auxiliary equipment.

Temperature considerations present formidable problems; however, none of them appears insurmountable. From this standpoint, the development of a practical magnetohydrodynamic electrical power generator would seem entirely possible.

This article is based on part of an Astronautic Symposium developed jointly by SAE and the Air Force Office of Scientific Research. The Symposium is available only as a book, titled "Vistas in Astronautics — 1960." To order, turn to p. 6.

At Fisher Body: Reliability



THE ORGANIZATION required to assume and control the responsibilities of a reliability program utilizes existing departments and manpower to the fullest extent.

The multifunctional nature of the reliability operation is such that any other approach would be costly and also breed inefficiency as a result of overlapping duties.

This chart shows the position of the reliability activity with respect to the other related functions. In this instance, a reliability policy board determines basic company policy with regard to the reliability program and renders advice and guidance on major or controversal items of a corporate nature.

The reliability coordination staff performs functions similar and subordinate to those of the policy board but with greater frequency.

The coordination staff meets as often as the work schedule demands, to review current and proposed action within the pattern of responsibilities of the reliability activity. The staff members occupy a position within their own activities from which they may promote harmony and cooperation, exercise authority and control with respect to initiated reliability measures.

The reliability engineers are, of course, a permanent staff on the day-by-day obligations. Each of the organizational functions is represented by a selected, experienced engineer.

Program upgrades car bodies

Birth of new tool results in better product and improved customer reactions. Article describes reliability organization and provides a perspective of what a reliability program can hope to accomplish by looking at some of the plus factors in body production today.

Based on paper by
William E. Sehn, Fisher Body Division GMC

Material drawn from an
SAE Detroit Section Paper

The functions of a reliability program . . .

- Control and utilize existing reliability facilities and functions.
- Prevent the recurrence of repetitive errors of design, manufacturing, and assembly.
- Resolve frequent customer complaints.
- Create and control new reliability measures.
- Create entirely new products, materials, or processes.
- Collect and evaluate data.

The RESPONSIBILITIES of the reliability group . . .

- Maintain close scrutiny of new product styling, development, and design, prior to its final acceptance for production.
- Analyze current design, engineering, tooling, fabrication, and assembly decisions.
- Investigate field service complaints and warranty costs.
- Evaluate quality with respect to both internal operations and purchased components.
- Evaluate product testing on both current and future products in the interest of establishing failure rates and standards of performance.
- Appraise the product output in comparison to its original specifications and determine any causes of off-standard product performance.
- Initiate measures directed toward the education of all personnel with respect to their obligations in assuring reliability of the end product.
- Establish lines of communication between interfunctional operations to promote the smooth interchange of information and data with respect to improving reliability.

Body Reliability at Fisher Body →

At Fisher Body: Reliability Program upgrades car bodies

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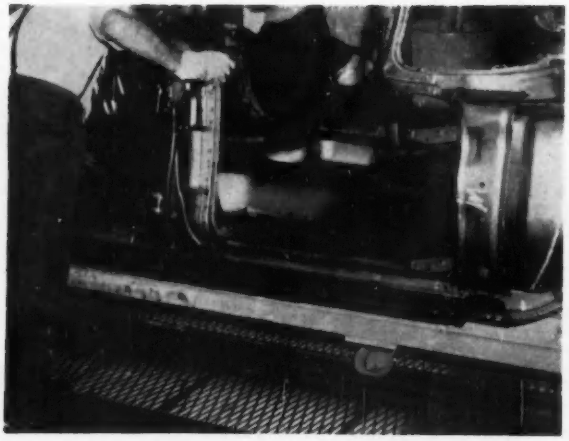
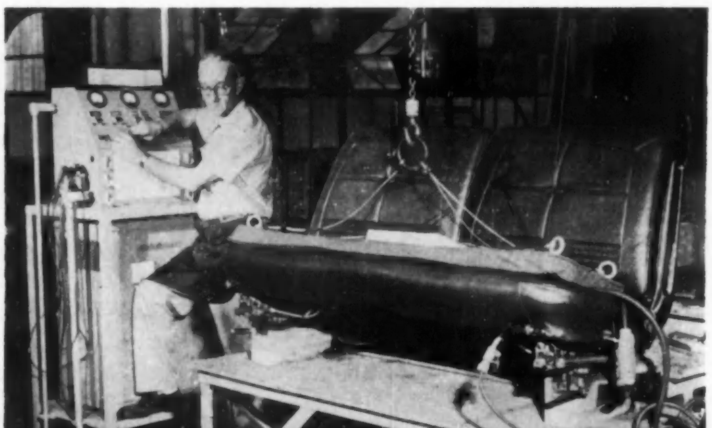
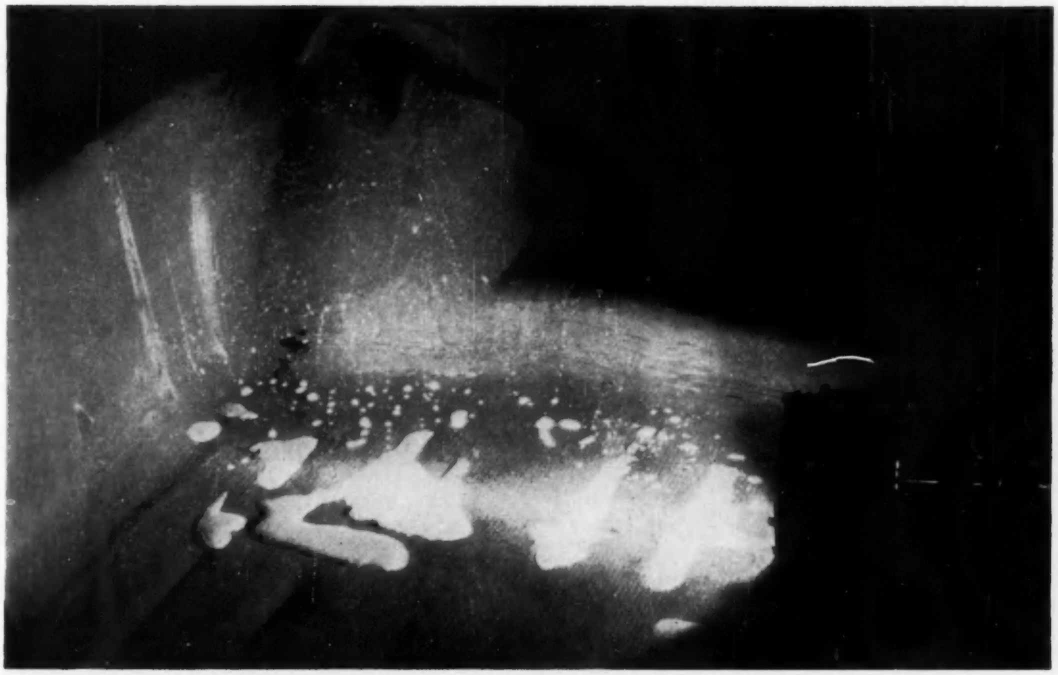


HIGH-INTENSITY LIGHTING IS INSTALLED UNDERNEATH THE BODY-IN-WHITE in the body shop. Inspection from inside the body reveals any opening which can be immediately repaired and sealed against water and dust.

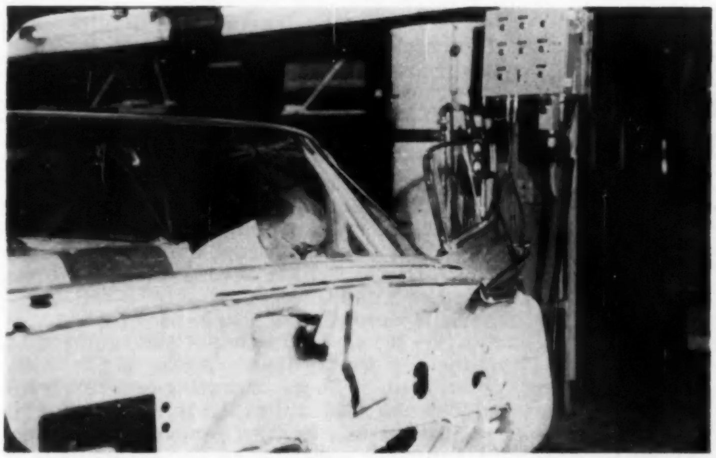
SIMILAR CHECKING OPERATION AFTER THE BODY HAS BEEN SEALED. Past practice relied on the water-test alone, which made detection of pinholes more difficult.



SPECIALIZED EQUIPMENT FOR TESTING 6-WAY POWER SEATS prior to assembly. The seat must perform through two consecutive cycles under 450 lb of weight with no deviation from the specified amperage, voltage, and time. By checking the reliability of the seat adjuster mechanism in this fashion, more positive assurance of complete dependability in service is guaranteed.



NEW INSPECTION PROCEDURE UTILIZES BLACKLIGHT PROJECTION UNITS. These instantly reveal the source of a water leak through the use of fluorescent dye in the water test booth. . Repair immediately follows with retesting in an off-line booth. Previous water test inspection methods very often resulted in misplaced seals, because the source of the leak was in question.



SPECIAL EQUIPMENT IS USED TO DETECT ELECTRICAL FAILURES in the body wiring. Development of equipment such as this provides the customer with additional confidence in the product.

To Order Paper No. S261 . . . from which material for this article was drawn, see p. 6.

Gas turbine diesel power in dual

Integrated unit for ground propulsion

Based on paper by

C. H. Paul and E. L. Kumm

AiResearch Mfg. Co., Division of Garrett Corp.

A WHOLE NEW HORIZON of gas turbine applications is in view as designers take aim on reducing the fuel consumption of these power units.

One new approach — for ground vehicle propulsion applications — achieves minimum specific fuel consumption while using a simple-cycle gas turbine. This nonregenerated turbine is integrated with a diesel engine . . . resulting in an efficient, versatile, lightweight, compact powerplant.

Fig. 1 shows the proposed dual powerplant. The gas turbine is used to supply the starting power for the diesel engine. At very low subzero temperatures, the gas turbine supplies hot gases to preheat the diesel engine and its fuel — and then start it. The gas turbine can, of course, be started at very low temperatures with comparative ease.

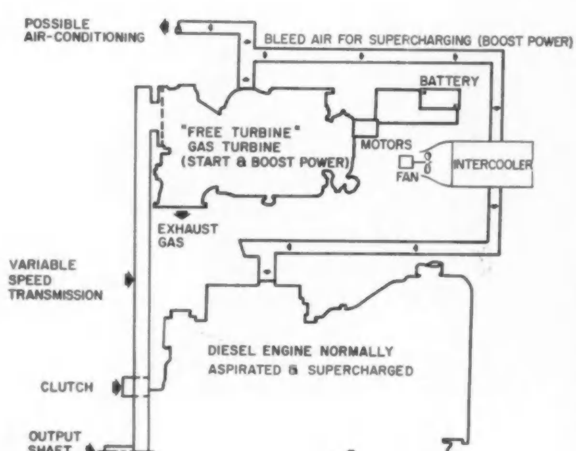


Fig. 1 — Gas turbine power boost for diesel engines.

The diesel engine can then be used efficiently over its lower power range in a normally-aspirated fashion, with the gas turbine not operating and declutched from the drive shaft.

Additional power demands can be met by both clutching in the gas turbine to the drive shaft and using the gas turbine to supply pressurized air to the diesel engine (supercharging). The output power may thus be increased in a major fashion.

Table 1 shows the wide power variation possible in such a combination by varying the gas turbine speed. A variable-speed transmission would permit operating the output drive at various speeds with respect to the gas turbine speed. The variable-speed transmission could be eliminated by using the gas turbine for bleed air only.

The gas turbine-diesel engine combination offers good fuel economy over a very large power range. The gas turbine can be operated with a wide range of fuels and, since the turbine is available for starting the diesel, the reciprocating engine can accept a much wider range of multifuel usage. All of the fuels shown in Fig. 2 have been used in the combustion can or flame tube shown.

Gas turbine bleed air can also be used for air conditioning (Fig. 3) or for heating. Air conditioning is becoming a necessary incorporation in advanced, large power equipment for improving operator comfort and increasing the utilization time of the equipment. Bleed air can be used for comfort heating directly, and large quantities of hot exhaust gas or bleed air are available to melt snow and ice.

In addition, the gas turbine is an additional or emergency power source — giving dual engine reliability to a vehicle.

To Order Paper No. 212C . . .
from which material for this article was drawn, see p. 6.

boosts powerplant

Table 1 — Using Gas Turbine to Boost Diesel Engine Power						
Diesel Power Output				Gas Turbine		Total Vehicle Bhp Required
Air Charge	Bmep, psi	Bhp per Cylinder	4-Cyl Bhp	Bhp	Bleed Airflow, lb/min	
Natural Aspiration	100	37.5	150	0	0	150
Low P/R Turbo	200	75	300	0	45	300
Inter P/R Turbo	250	95	375	125	55	500
High P/R Turbo	300	112.5	450	200	65	650

gives low sfc, low-temperature starting.

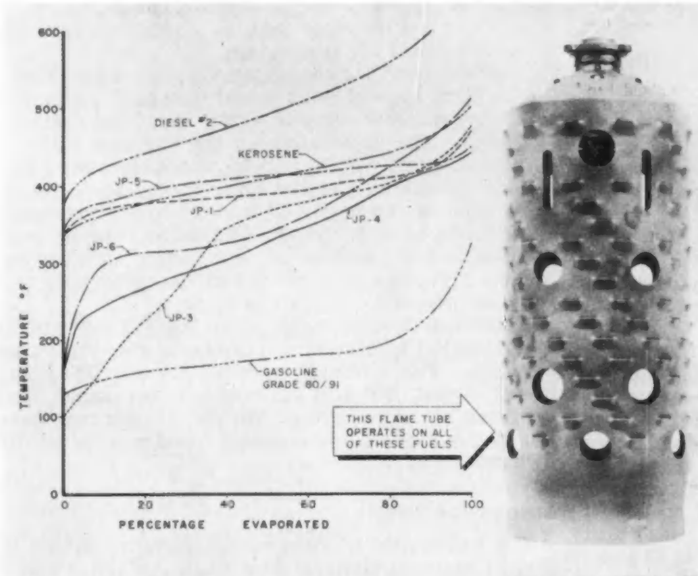


Fig. 2 — Gas turbine fuel experience.

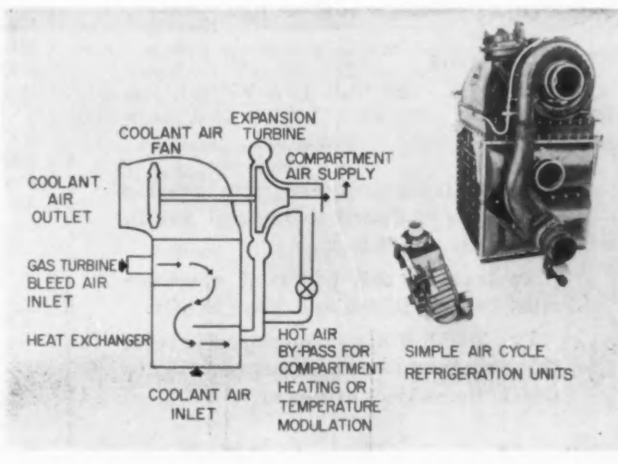


Fig. 3 — Air cycle air conditioning system.

Musk-Ox Licks Muskeg

Unique vehicle will transport 20-ton payloads over near-bottomless bogs to open up oil lands

Based on paper by

C. J. Nuttall, Jr.

Wilson, Nuttall, Raimond Engineers, Inc.

and **J. G. Thomson**

Imperial Oil, Ltd.

AN OFF-THE-ROAD VEHICLE to transport heavy oil exploration equipment over terrain which has virtually no load-bearing strength has been developed by Wilson, Nuttall, Raimond Engineers, Inc., for Imperial Oil, Ltd. of Canada.

The Musk-Ox, shown in Fig. 1, is a tracked-tractor, power-tracked-trailer combination, steered by controlled-joint articulation and capable of transporting a payload of 20 tons at a speed of 10–15 mph.

Overall length of the vehicle is approximately 50 ft. Overall width has been held to 10 ft to facilitate moving over roads and to simplify rail shipment. The engine, transmission, winch, cab, and fuel are carried on the front unit. Power is transmitted through the narrow belly (16 ft between tracks) to rear sprockets on each unit. Power for the rear unit is transmitted through the center of the joint.

The final weight of the vehicle, ready to load and including many husky field extras, is about 30 tons. In spite of this heavy weight, the full-load, nominal, unit ground pressure is only 3.4 psi.

Musk-Ox chassis

The frame of each unit is a welded, low-alloy steel backbone with deck frames and suspension axles cantilevered from it. The entire load is carried through four stub axles on the front and six on the rear, each with a two-wheel bogie. The wheels are connected to each walking beam through a supplemental air suspension.

The two units are connected through a two-piece, gimbal-ring type of joint permitting both pitch and roll freedom between the units about axes within the joint. The joint angle in the steering plane is controlled positively by a pair of double-acting hydraulic cylinders, and the driveline passes through the center of the joint. The overall joint geometry is so arranged as to transmit shaft rotation at constant speed regardless of roll, pitch, or steering angle. Fig. 2 gives some idea of the pitch and roll freedom and also shows the joint.

Single, split, cast magnesium alloy road wheels are mounted to standard Timken trailer hubs and spindles. The tires are special, smooth, 30 × 9 in., 20-ply nylon, built in an aircraft tire mold, and operated at a pressure of 120 psi. Punctures have not been a serious problem and tread wear is hardly measurable at 3000 miles.

Suspension details

The automatic air-suspension system (shown in Fig. 3) employs General Tire 14-in. air pillows at a pressure of about 120 psi. Automatic leveling valves on the first, third, and last bogies on each side respond to the 3 deg of freedom in leveling in the fore and aft centerline plane. The pressures in bogies two and four are governed by a special valve at the average between the two adjacent bogies on the same side. The pressure to the five units on a side are determinate at all times and the resulting load distribution is nearly equal. The system has functioned without serious difficulty for over a year, but a leveling valve actuating arm has been amputated on occasion. In future vehicles each valve will be wholly enclosed.

Track of the Musk-Ox

The band-type track is made of rubber-covered, nylon-rayon, fabric belts to which are bolted 52-in. wide, cast-steel grouser bars (Fig. 4). The belts are 8 in. wide and 1 in. thick and have a breaking strength of approximately 60,000 lb each. Four

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MUSKEG is a sphagnum moss covering vast areas of Canadian mineral wealth to a depth of 1–60 ft.

To traverse this bog land a vehicle must be sure-footed and tread lightly.

The MUSK-OX was developed to solve this transportation problem and its design is the subject of this article.

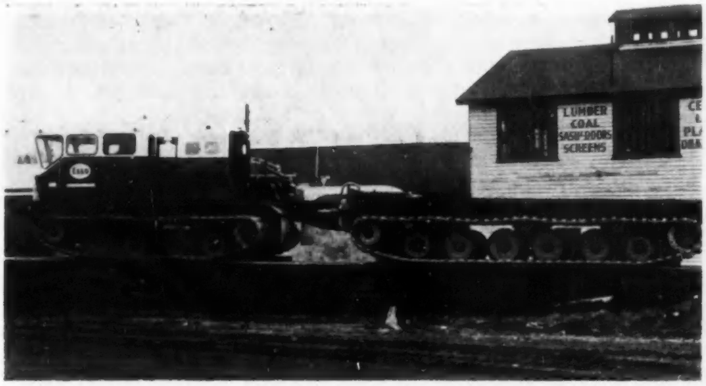

Fig. 1 — This muskeg-traversing Musk-Ox is 50 ft overall and carries a 20-ton payload at a top speed of 14 mph. It is a bellyless, low ground pressure vehicle, steered by controlled-joint articulation.

Fig. 2 — A two-piece, gimbal-ring type of joint connects the two units of the vehicle to permit extreme pitch and roll freedom between the units about axes within the joint.

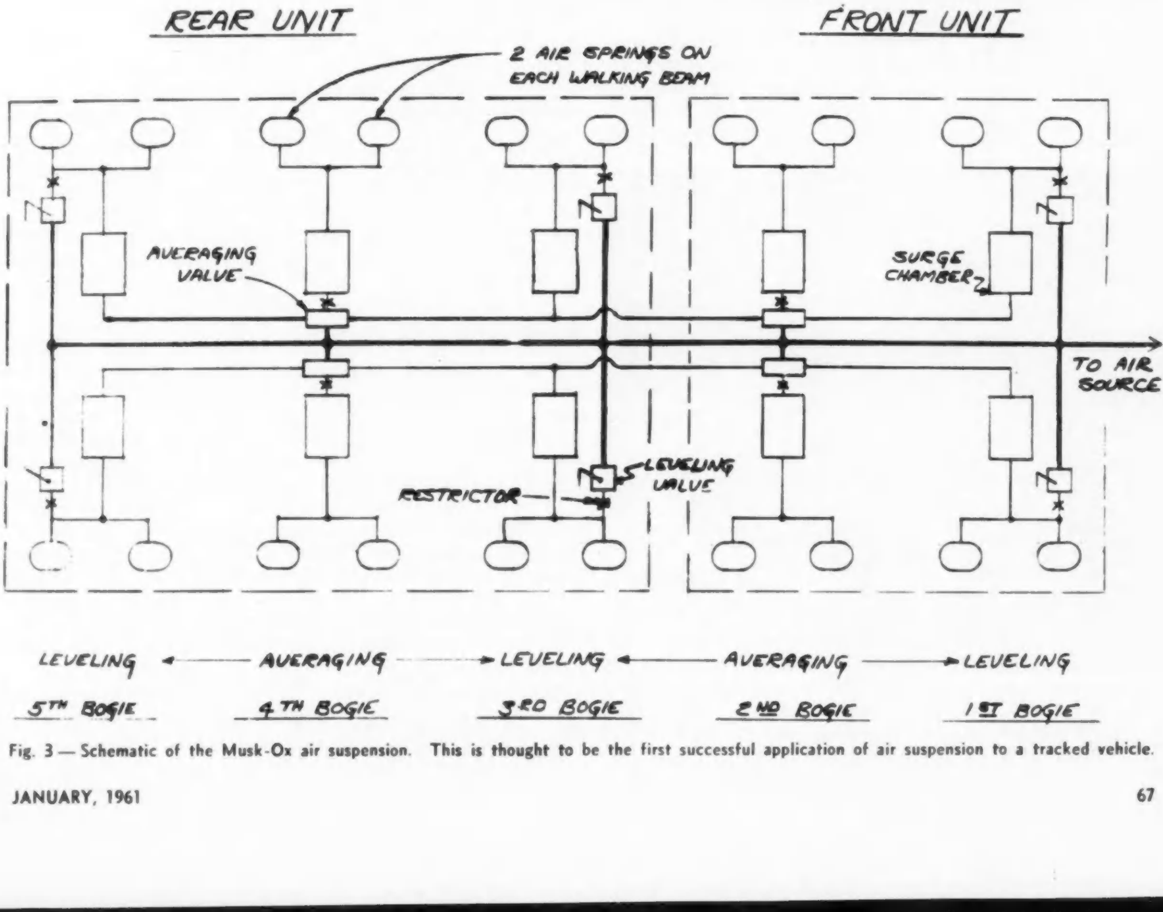

Fig. 3 — Schematic of the Musk-Ox air suspension. This is thought to be the first successful application of air suspension to a tracked vehicle.

Musk-Ox Licks Muskeg

. . . continued

belts constitute the continuous element of each track and each belt is in sections of about 12 feet, joined by long diagonal splices which cross a number of grousers. Belt life has been good even though a section of the belt between grousers has been punched out on occasion. About three-quarters of the original belts are still in use after 3000 miles of rugged use. Some appear to have half their life still left.

Failure of a single belt does not immobilize the vehicle. The fabric-base belt has more stretch than desirable and the use of belts with steel cable stretch members or heavier fabric will be explored.

The 52-in. track shoes are made of heat-treated, cast steel and weigh 37 lb each. They are bolted to the belts with stamped steel backing plates on the inside of the belt. Cast magnesium alloy backing plates — used originally to save weight — proved too brittle. Future vehicles will have forged aluminum plates. Track throwing has never been a problem in spite of the great length of the tracks on the rear unit. This is attributable to the guide design, articulated steering, and close control of the wide track at both sprocket and idler.

Sprockets and idlers

Sprockets and idlers were designed with great care to provide positive spatial positioning of the tracks in all respects at these important points. This, together with the single road wheel path and female guiding system, has proved most effective. In rare cases where the road wheels have run out of the female guide path they have run back in immediately when the external loading causing the displacement has been relieved by further vehicle motion.

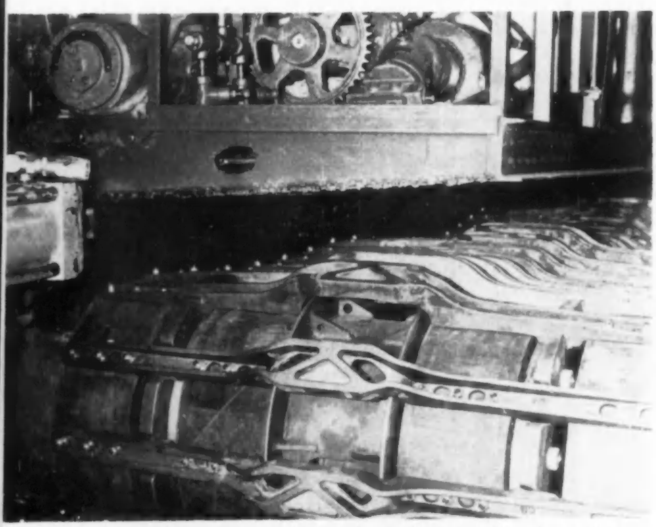

Fig. 4 — Band track on the sprocket of the Musk-Ox. Four belts from a continuous track. Cast steel grousers are bolted to the belts which have a breaking strength of about 60,000 lb each and have excellent wear life.

Pneumatic tires were fitted originally on the front idlers, but steel sprockets have been substituted because of the difficulty of making changes in the field.

Sprockets, originally 1-in. 4140 steel plate, are now 2 in. wide, cast, heat-treated Nicromel steel. They have run 1500 miles without showing serious wear and their relative hardness assures that wear will occur on the easily replaced sprockets rather than on the grouser bars.

Diesel power train

The Musk-Ox is powered by a Cummins NRTO-6, turbocharged, 6-cyl diesel engine, developing 335 hp at 2100 rpm. It faces aft and is cooled by an oversized radiator and blower fan. It drives forward through a torsionally damped Spicer 1700 series propeller shaft to a remotely mounted Allison CLBT-5640 Torqmatic transmission which incorporates a torque converter with lockout, a retarder, four speeds in semi-automatic array, and a drop case.

Power is taken from the rear take-off on the drop case by a propeller shaft and fed into a Timken interaxle differential incorporated in a Cotta two-gear drop case. This differential can be locked at the driver's option, but is normally open so that all four tracks receive substantially equal torque at all times. Drive out of the rear of the case is on two drivelines, one to each of two axles. The driveline from this point through the joint to the rearmost axle incorporates seven separate shafts.

In addition to the retarder in the transmission, standard truck 16×5 in. air/hydraulic brakes are fitted to each rear sprocket on the front unit, and a propeller shaft parking brake is on the front take-off of the transmission drop case.

Steering system

Steering is accomplished by hydraulic cylinder actuation of the joint. The cylinders are controlled by a hydraulic servo valve of the type which meters the oil as the steering wheel is turned and thus follows up without a mechanical connection. The system has worked without fault and driver fatigue is non-existent.

Performance on the job

Over 3000 rugged miles have been put on the Musk-Ox despite its being out of service for repairs and debugging for perhaps half the time. It has put out approximately 25,000 ton-miles of useful cargo movement, which is believed to be some sort of record for really difficult cross-country operation.

The initial cost of tonnage carrying special muskeg vehicles (in the quantities likely to be required) is of the order of \$4000-\$6000 per ton of capacity. This is high and there appears to be little that can be done to reduce it. Only first-class components and workmanship will suffice for a machine of the size and complexity of the Musk-Ox which can fail in so many ways.

To Order Paper No. 213B . . .
from which material for this article was drawn, see p. 6.

Maxwell elements step up the accuracy of simulating

RUBBER DYNAMICS

Based on paper by

R. E. Newton,

U. S. Naval Postgraduate School and

Lyle E. Matthews,

Naval Missile Center

IMPROVED simulation of rubber shock and vibration isolation mounts comes with the use of Maxwell elements. This series combination of spring and dashpot is the key to computing two of the unusual properties of rubber. These properties are:

- Increasing stiffness under dynamic conditions.
- Stress relaxation following a suddenly applied force.

The mechanical model shown in Fig. 1 closely approximates rubber properties by combining a Maxwell element (right-hand side) with a spring. In operation, if the unit is *slowly* extended, the right-hand spring will be relaxed and the stiffness of the system is equal to the left-hand spring. But if the extension is *rapid*, the right-hand spring becomes effective and the system stiffness approaches the sum of the two springs. This covers the changing stiffness of rubber under dynamic loading.

At the same time, the model accounts for the relaxation of force with time after a suddenly applied load. After a rapid extension of the system, the dashpot will continue to unload the right-hand spring, thus reducing the total force between the ends of the system.

The one property of rubber that the model doesn't simulate is the nonlinear behavior associated with high strains. Also, variations due to temperature are ignored.

Working from the theory of molecular bonds in high polymers, physical chemists have postulated that a truly representative model must have an indefinitely large number of Maxwell elements in parallel. If the polymer is crossed-linked, there will be one unit in which the dashpot is infinitely sluggish, which reduces this unit to a pure spring. For many shock and vibration problems, a model using a spring and two Maxwell units, as shown in Fig. 2, will suffice. For the purposes of comparison, this

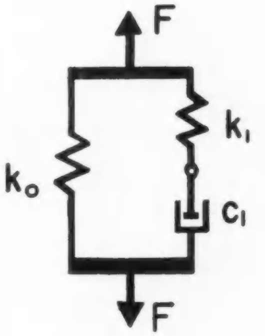

Fig. 1 — Maxwell model can simulate the changing stiffness and stress relaxation characteristics of rubber.

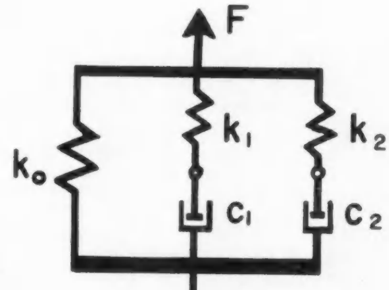

Fig. 2 — Although physical chemists predict that an infinite number of Maxwell elements are needed to completely represent high polymers, a 3-unit model reasonably simulates test results. Cross-linked polymers require that one element be a spring only.

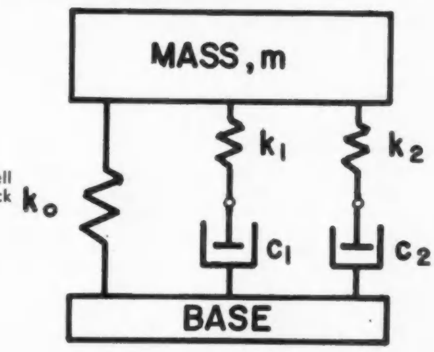

Fig. 3 — Maxwell model as a shock isolator.

Rubber Dynamics

. . . continued

Symbols

a = Amplitude of sinusoidal motion, in.
c = Damping constant, lb-sec/in.
F = Force transmitted by elastomer, lb
F_d = Force transmitted by dashpot, lb
F_M = Force transmitted by Maxwell element, lb
F_s = Force transmitted by spring, lb
k = Spring stiffness, lb/in.
k' = In-phase (elastic) component of dynamic stiffness, lb/in.
k'' = Quadrature (damping) component of dynamic stiffness, lb/in.
m = Mass, lb-sec^2/in.
u = Support (absolute) displacement, in.
x = Deflection of elastomer model, in.
y = Spring extension, in.
$\dot{z}$ = Dashpot piston velocity relative to cylinder, in./sec
δ = Displacement step, in.
τ = Relaxation time for Maxwell element, sec
ω = Circular frequency of sinusoidal motion, rad/sec

Table 1 — Comparison of Shock Responses for Maxwell Model and Conventional Model

	Velocity Step		Velocity Pulse
	Maximum Deflection, in.	Maximum Acceleration, g	Maximum Acceleration, g
Maxwell Model	2.5	8.7	2.6
Conventional Model	2.1	8.2	4.8

3-element model was checked against the physical characteristics of rubber in shear.

Analysis of the model

When a spring and dashpot are in series, the kinematic relation is:

$$\dot{x} = \dot{y} + \dot{z}$$

and the force relation is:

$$F_M = F_d = F_s$$

where:

$$F_d = c\dot{z} \text{ (dashpot)}$$
$$F_s = ky \text{ (spring)}$$

Eliminating $\dot{z}$ gives:

$$c\dot{y} + ky = c\dot{x}$$

or:

$$\tau\dot{y} + y = \tau\dot{x} \qquad (1)$$

where $\tau = c/k$ is called the relaxation time of the Maxwell element. To find the force F_M, it is necessary first to solve Eq. (1) for y using a particular time history of x (and $\dot{x}$). F_M can then be found from:

$$F_M = F_s = ky$$

For a new time history of x, it is necessary to repeat the process. It is not possible to eliminate the time and express F_M in terms of only present values of x and $\dot{x}$.

Maxwell Model—The behavior of the Maxwell model shown in Fig. 2 is found by adding the force contributions of the individual elements. Thus:

$$F = k_o x + k_1 y_1 + k_2 y_2,$$

where y_1 and y_2 are given by:

$$\tau_i \dot{y}_i + y_i = \tau_i \dot{x}, \qquad (i = 1, 2) \qquad (2)$$

and:

$$\tau_i = c_i/k_i$$

The results of analysis for two important force-time variations (step function and sinusoidal) are:

1. Step Function: A true step function is possible for the Maxwell model because each parallel element can act as a true spring. In conventional models, the spring

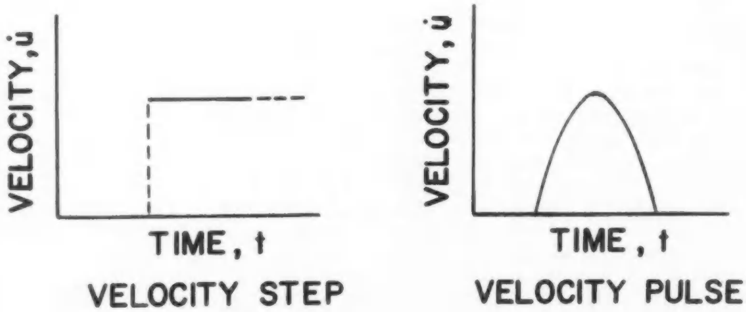

Fig. 4 — Two different input velocity profiles can be used to demonstrate how the Maxwell model follows the performance of an elastomer while conventional models give spotty results.

and dashpot are in parallel and the dashpot limits the rate of extension of the unit.

A step function produces an extension so rapid that there is no significant relaxation of the Maxwell elements during the process. The subsequent variation of force is given by:

$$F = k_o\delta + k_1\delta \exp(-t/\tau_1) + k_2\delta \exp(-t/\tau_2)$$

where t is the time elapsed following the displacement.

2. Sinusoidal Displacement: The sinusoidal displacement can be represented by:

$$x = a \sin \omega t$$

The response of a single Maxwell element to this motion is found by substituting in equation (1), finding the steady-state solution for y, and then evaluating:

$$F_M = ky = \frac{(\omega\tau)^2}{1 + (\omega\tau)^2} ka \sin \omega t + \frac{\omega\tau}{1 + (\omega\tau)^2} \text{ka} \cos \omega t$$

From this the elastic and damping components of dynamic stiffness are:

$$k'_M = \frac{(\omega\tau)^2}{1 + (\omega\tau)^2} k; \qquad k''_M = \frac{\omega\tau}{1 + (\omega\tau)^2} k$$

The dynamic stiffness components for the Maxwell model are obtained by summation:

$$k' = k_o + \sum_{i=1,2} \frac{(\omega\tau_i)^2}{1 + (\omega\tau_i)^2} k_i$$

$$k'' = \sum_{i=1,2} \frac{\omega\tau_i}{1 + (\omega\tau_i)^2} k_i$$

For the simple case of mass (m) with vertical translation only, the equation of motion of the mass is:

$$m\ddot{x} + k_o x + k_1 y_1 + k_2 y_2 = -m\ddot{u} - mg$$

where u is the motion of the base relative to an inertial reference frame. (See Fig. 3.) Values of y_1 and y_2 are first found from equation (2). Solutions for specified shock motions (u) are generally found by computer techniques.

Advantage of the Maxwell model

The Maxwell model will accurately represent an elastomer over a wide variety of shock and vibration motions, while the conventional representation of elastomers (a spring and dashpot in *parallel*) may give grossly inaccurate answers for some types of input motion.

An example of the difference in results between Maxwell and conventional models is illustrated by two inputs illustrated in Fig. 4. The comparison of shock response is shown in Table 1. The velocity pulse produces an acceleration almost 100% too high in the conventional model because the dashpot accounts for most of the force at peak velocities. The Maxwell model cannot develop high dashpot forces until the series springs are first compressed.

To Order Paper No. 236B . . .
from which material for this article was drawn, see p. 6.

Algal System Challenges Engineers

Based on paper by
J. J. KONIKOFF
General Electric Co.

USE of algae to supply oxygen to man in space is not the panacea often described in Sunday supplements. The relationship between man and plant whereby man donates carbon dioxide to the plant and the plant gives back oxygen to the man is a seemingly simple, well known, and understood relationship. Nevertheless, cold, hard engineering of a high order and quality must be applied just to catch up with the plant physiologist. And this is the major problem associated with the design of the photosynthetic gas exchanger.

To apply the photosynthetic mechanism to space use is a challenge to the engineer. A successful algal system will be developed, but certain fundamental problems must be solved to do it. Here are ten major ones:

1. Balancing the R.Q. (ratio of CO_2 volume evolved by respiring cells or tissues to volume O_2 consumed) with the A.Q. (ratio of volume of CO_2 taken up by the plant to the volume of O_2 evolved), including the effect of the nutrient supply and type of the plant A.Q.

2. Gas separation techniques.

3. Processing of human excreta as a source of nutrient for algae.

4. Selection of optimum algal strains (not a true engineering problem, but engineering requirements are involved).

5. Use of algae for human food.

6. Energy supply to the algae culture, which is basically a problem of illumination engineering and geometry.

7. Control devices for: (a) temperature, (b) turbulence, (c) density and (d) nutrient supply balance.

8. Small, highly reliable, centrifuging devices for separation, drying, and the like.

9. Design of the overall photosynthetic gas exchange system capable of operation in a zero g environment.

10. System design of a photosynthetic gas exchanger.

These ten points lead to many subproblems; however, their solution can only be undertaken by an engineering approach to the gas exchange problems introduced by placing a man in space.

To Order Paper No. 244C . . .
from which material for this article was drawn, see p. 6.

X-Ray Diffraction Measures

Even in Hard

Diffractometers better than

X-RAY MEASUREMENT of residual stress in hard steels by the two-exposure method and use of diffractometers has an absolute accuracy of 5000–10,000 psi. . . . And it measures relative stress levels with a precision of 4000–5000 psi.

Stress measurement by X-ray diffraction is based on measuring strain — and then converting it to stress by equations developed in the classical theory of elasticity. This method will detect elastic strains only, since it is fundamentally a measure of interatomic spacings which are altered by elastic stresses.

(The X-ray technique is strictly valid for measurement of stress in a material which is elastic, homogeneous, and isotropic. . . . Polycrystalline metals to a good approximation satisfy these requirements.)

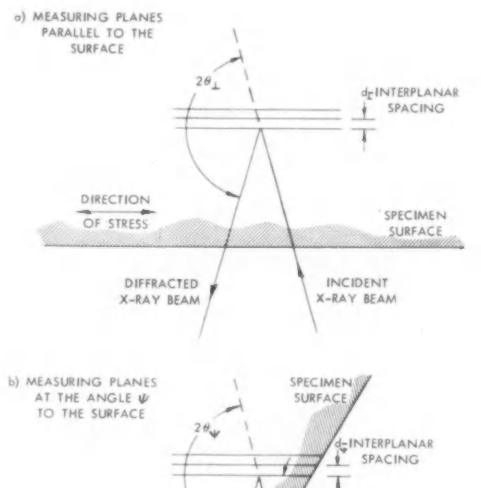

Fig. 1 — Two-exposure X-ray diffraction method, showing lattice planes measured to direction of stress.

Stress-strain relation

Fig. 1 illustrates the basic principle of the two-exposure X-ray diffraction method of measuring residual stresses. Interplanar spacing of a selected family of atomic planes in the phase under study is used to indicate elastic strain present. This interplanar distance (*d*) is determined at two angular orientations (ψ) of those planes to the surface direction in which it is desired to measure the stress. Common procedure is to determine the *d* value of the planes parallel to the surface ($\psi = 0$ deg) and again at same chosen angle of ψ (usually 45 or 60 deg oblique to this direction). There is then a convenient equation for obtaining the stress from changes in interplanar spacing.

Either film or diffractometer X-ray diffraction techniques can be used for the measurement of the interplanar spacings. When using the diffractometer (the preferred method for diffuse lines), the data are obtained in terms of the angular position, 2θ. So it is convenient to express the stress in terms of 2θ rather than the interplanar spacings.

For maximum sensitivity of stress measurement, it is desirable that the difference in interplanar spacing be reflected by as large as possible change in diffraction angle. So it is important to choose the proper combination of wave length of radiation and family of crystal planes to provide as large a diffracting angle as possible. Sensitivity of stress measurement rapidly decreases as the angle 2θ becomes smaller than 130 deg.

For stress measurements on a given material — for example, hardened steel — the terms not involv-

Stress

Steel

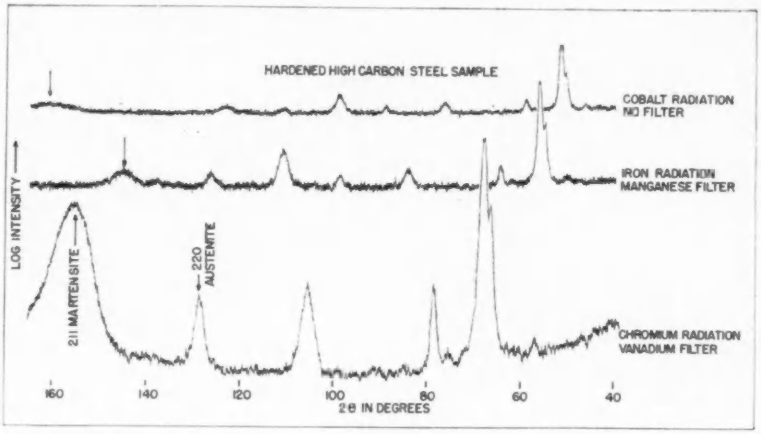

Fig. 2 — Diffraction pattern from hardened steel using various radiations. All traces are plotted to the same intensity scale.

film measurements.

ing the θ angle are constant. If the technique is standardized with respect to ψ angles, for a given material the constant term may be lumped.

Thus the stress is proportional to the shift in the diffraction angle 2θ as the angle ψ is changed. The constant is referred to as the stress factor. Present practice involves calibration of the spectrometer unit in order to assign a numerical value to the stress factor.

Stress factor

Young's modulus (E) and Poisson's constant (ν) enter into the stress factor and are fundamental properties of the material being examined. The "bulk" or average values of these constants are readily available for most polycrystalline materials.

However, if a puristic approach is followed, use of these bulk values in the computation of stress by X-ray measurements is open to criticism. In deriving the stress equation, the material was assumed to be isotropic. Most crystalline materials — such as iron — are not isotropic and their elastic properties vary with crystal direction.

Values of E and ν under conditions of X-ray stress measurement may vary considerably from the bulk E and ν values determined for polycrystalline metallic materials. Fortunately for X-ray stress measurement the material doesn't have to be isotropic. . . . If the values of d and 2θ are always determined at two specific angles, the difference in d or 2θ will always be proportional to the stress despite any difference in E or ν that may exist at those angles.

For these reasons it is advisable to determine experimentally — by the use of electrical resistance strain gages — the X-ray stress factors for materials being studied.

Additional reasons for resorting to calibration procedures include the hazard of the measuring techniques used influencing the stress constant, and the desirability of obtaining an X-ray stress value (fictitious though it may be) that correlates with regular strain gage data.

Experimental Technique

Diffractometer versus film

Direct-reading diffractometers have the advantage over film when measuring diffuse diffraction lines. This is because the contour of the diffuse diffraction line (and therefore, its apparent position) is influenced markedly be certain θ-dependent factors. . . . Corrections for these factors are easily applied to the direct intensity measurements of the diffractometer and are difficult to apply to film blackening measurements.

A second advantage is the improvement in diffraction line contrast — peak to background ratio — possible from the monochromating characteristics of the X-ray counting tubes, circuitry, and filtering techniques adaptable to diffractometers.

Radiation and filter

In the past, cobalt or iron radiation have been used when investigating stress in steel. Both of these radiations furnish a ferrite or martensite line in the desirable 2θ range of 140–165 deg and are excellent selections when the steel hardness is sufficiently low that sharp lines are obtained.

When steel hardness is high, there is an advantage to using chromium radiation with a 0.001 in. thick vanadium foil filter in the diffracted beam, as shown in Fig. 2. Using chromium radiation, the martensite 211 planes diffract at about 156 deg (2θ) and the 220 austenite line is available at 128 deg — which is a little lower 2θ angle than desired for sensitivity of measurement but is adequate for the purpose.

In the absence of austenite, it is possible to attain a ratio of line intensity to background of 5 or 10/1 instead of the more commonly encountered ratios of 1.2 or 1.5/1.

Location of diffraction peak

To determine the interplanar spacings to a precision adequate for stress measurement, the 2θ angles

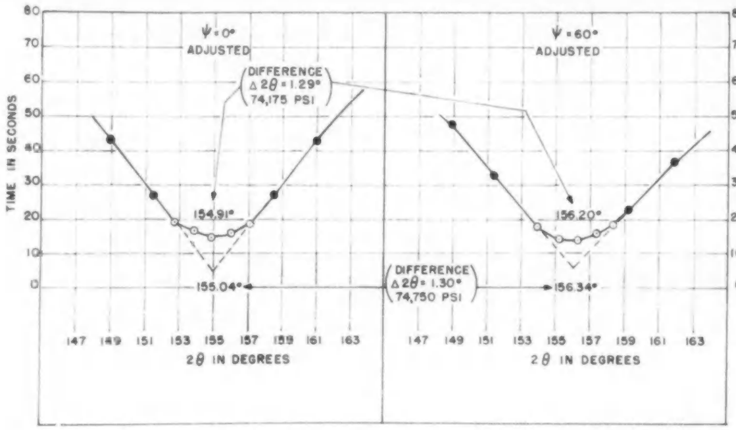

Fig. 3 — Line positions determined by extrapolation of line sides and by fitting parabola to line peaks.

Fig. 4 — Variation of relative intensity of angle 2θ resulting from the Lorentz-Polarization factor.

THIS article is based on material drawn from TR-182. This technical report was prepared by the X-Ray Subcommittee of Division 4 — Residual Stresses and Fatigue — of the SAE Iron and Steel Technical Committee.

Members of the Subcommittee include:

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General Motors Corp.
R. E. Marburger
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M. Semchyshen
Climax Molybdenum Corp.
W. P. Evans, subcommittee chairman
Caterpillar Tractor Co.

TO ORDER TR-182, see p. 6.

X-Ray Diffraction Measures Stress

. . . continued

of the diffracted rays must be measured with an accuracy of 0.02 or 0.03 deg.

Absolute positions of diffuse lines can't be determined with certainty. However, if relative angular positions can be assigned to broad lines, those positions suffice for determination of stress.

Then the peak position may be obtained either by extrapolating the line sides or by fitting a parabola to the peak of the line.

The method of extrapolating the line is limited in usefulness to measurements on hard steel. These line sides of diffuse lines obtained from hard steel are linear over a considerable range of 2θ, and the linear portions of their sides can be extrapolated to their intersection. The angle 2θ at the point of intersection is selected as the line position. This method is cumbersome, time-consuming, and applicable only to lines with reasonably linear sides. As line sharpness increases, the degree of linearity of line sides is grossly reduced.

On the other hand, the parabolic method lends itself to any degree of line sharpness, enables the measurements to be conducted at the highest intensity levels of the lines, and permits the closest approach to parafocussing conditions. In this method, the peak position is defined as the vertex of a vertical axis parabola fitted to the most intense portion of the diffraction peak. Five data points can be obtained about the diffraction peak — or the computation can be simplified by using three data points.

Fig. 3 shows the position measurements made on a pair of lines by extrapolation of line sides and by the parabola fitting method. Absolute positions of these lines vary with technique, but the shifts in position with change in ψ angle agree within 0.01 deg with the two procedures.

Usefulness of the parabolic method depends on how well the diffraction peak is represented by a simple parabola. This in turn depends on the line symmetry. A little asymmetry is introduced into

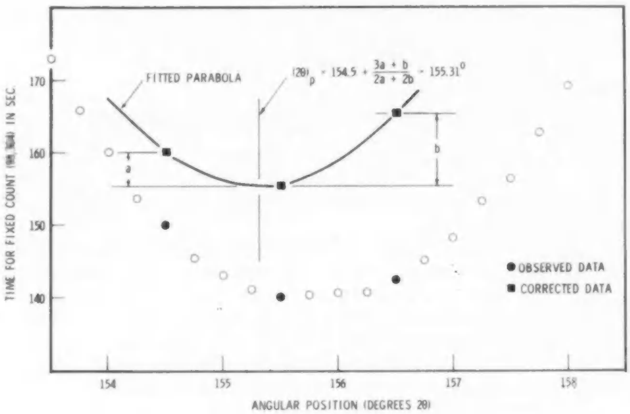


Fig. 5 — Peak position as determined from parabola fitted to corrected X-ray intensity data for $\psi = 0$ deg.

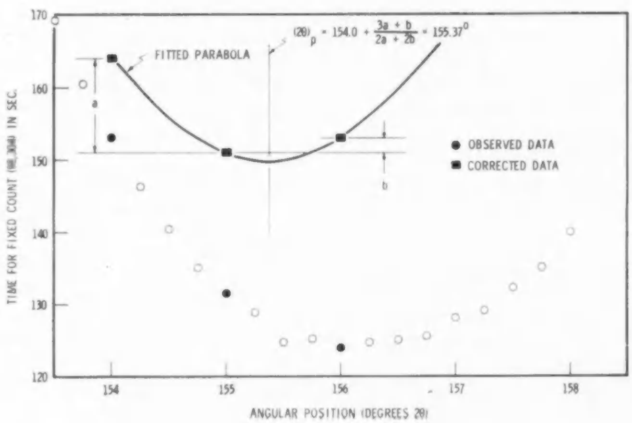


Fig. 6 — Peak position as determined from parabola fitted to corrected X-ray intensity data for $\psi = 60$ deg.

every diffraction line by certain θ-dependent factors entering into the diffraction and measuring process. Although these intensity factors vary slowly with θ, in the special case of diffuse lines the lines extend over a sufficient 2θ that these factors markedly affect the line contour and apparaent position. Hence all board line intensity measurements must first be corrected before a relative position is assigned to the line.

In the three-point parabolic method, it is desirable that the three selected points have intensities at least 85% of the maximum intensity and straddle the peak of the diffraction line after they have been corrected for intensity factors dependent on 2θ.

Correcting line measurements

The θ-dependent factors — of interest in the measurement of broad lines — are known as the Polarization, Lorentz, and absorption factors.

In most tables of correction for X-ray intensities, the Lorentz and Polarization factors are combined. Values of this factor over the 2θ range of interest are plotted in Fig. 4.

The absorption factor is of importance when the mean path length of the X-rays within the sample varies with the angle of diffraction. So when $\psi = 0$ deg, the path length, and hence the absorption constant are constant and independent of the angle θ. The only correction to be applied in this case would be the Lorentz-Polarization faction factor. However, at all specimen angles of ψ other than zero, the absorption becomes a function of the diffraction angle θ and the diffracted intensity varies.

Using the diffractometer

Modern diffractometers are provided with both rate meter and scaler circuits. The rate meter, the output of which is automatically recorded as a function of the diffraction angle, provides a more or less instantaneous average of the X-ray diffraction intensity. The scaler circuit permits the accumulation and measure of the total number of X-ray counts or photons for a given interval of time or the measure of time required to accumulate a given number of counts. The former is fixed-time scaling and provides a direct measure of X-ray intensities. The latter is fixed count scaling and results in the measure of inverse intensities. In measuring diffuse lines the output of the rate meter is neither sufficiently accurate nor sufficiently sensitive for stress determination. Scaling must be used and fixed-count scaling is the better technique, since it enables the choice and use of a constant probable error.

In the three-point parabolic method (Figs. 5 and 6), the peaks of the diffraction lines are fixed-count scaled at constant 2θ intervals suitable for outlining

X-Ray Diffraction Measures Stress

. . . continued

the particular lines being measured. These initial measurements are made rapidly by accumulating only a relatively low number of counts (10,000 or less) at each 2θ position. From these data points, positions of 2θ are selected for a more accurate determination of the inverse intensities. Final determination of inverse intensities at each of the three points is made by accumulating around 100,000 counts for each point.

Measured inverse intensities are multiplied by the Lorentz-Polarization factors to correct data at $\psi = 0$ deg, and the combined Lorentz-Polarization-absorption factors are used at angles of ψ other than zero. The vertex of the parabola that will fit these three points is then computed.

Surface treatment of specimens

X-rays of the wave lengths used for diffraction penetrate metal surfaces only superficially. This creates a problem. . . . For reliable stress measurement the specimen surface must be clean and smooth; but any mechanical procedure for cleaning or smoothing the surface will at least superficially disturb it — and render it unfit for stress measurement by X-rays unless the disturbed layer is removed.

Electropolishing seems to be the best method for smoothing or taking off stock. Mechanical procedures may be used if the distributed layer is then removed by electropolishing.

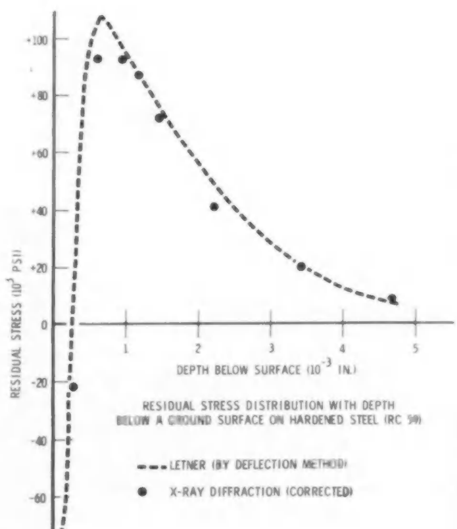


Fig. 7 — Comparison of stress measurements by X-ray and the precision deflection (Letner) method. X-ray measurements have been corrected for effect of X-ray penetration.

Accuracy of Stress Measurement

There is no serious problem is measuring stress differences or relative stress levels. X-ray stress measurement is easily calibrated against electrical strain gages.

Unfortunately, strain gages can't measure absolute stress and there is, therefore still difficulty in evaluating the accuracy of the individual X-ray stress measurement. For example, stress measurement in hard steel had no other technique against which the X-ray method could be checked until recent years. The development of a precision deflection (Letner) method for measuring stress — applicable to hardened steel — now enable a cross-check to be made. Comparisons with this technique (Fig. 7) added much to the confidence of those using the X-ray approach.

In checking instrumental alignment and accuracy, resort is usually made to carefully annealed specimens providing sharp diffraction lines. Unfortunately, after having been satisfied by use of these samples that alignment is adequate, operators frequently obtain values of 3000–10,000 psi in diffuse line samples that they feel ought to be stress free. It is possible that much of the stress observed in any given phase might actually be presented from interaction between phases. . . . So the best procedure is to align mechanically the instrument as perfectly as possible, using annealed single-phase materials yielding sharp diffraction lines for checking, and accept without alteration the stress values that are observed in other samples. The foregoing is what has created the uncertainty in absolute accuracy of the X-ray stress measurements.

Effect of beam penetration

Penetration of the X-ray beam into the metal surface is very low. Nevertheless, there are occasions (such measurement of grinding or honing stresses) when the stress may change sufficiently rapidly with depth that the X-rays will provide only a measure of the average stress over their depth of penetration instead of the true values. The X-ray measurements can be corrected for sharp gradients — the data in Fig. 7 have been so corrected.

Stress Measurements in Depth

Because X-rays are diffracted from surface layers only, a determination of residual stress in depth requires removal of material to the depth desired. When stress layers are removed, the successively measured stresses at depths below the surface must be corrected by an amount proportional to the relaxation created by the removed layers. This means that all the determinations except the initial value at the surface must be corrected in order to obtain the true stress which existed before the layers were removed. These corrections for several geometric shapes have been determined from the theory of elasticity, and are expressed as functions of the successively measured stresses.

European small diesel comes of age

in light commercial vehicles

Based on paper by

J. G. Dawson,

director of engineering
F. Perkins, Ltd.

THE USE of diesel engines has spread to smaller and smaller commercial vehicles in Europe and a trend in that direction is beginning in the United States. How fast these 400 cu in.-or-less diesels are adopted for small vehicles and industrial applications depends primarily on the availability of suitable engines.

The gasoline engine now dictates transmission and installation requirements and this will go on until the diesel wins a larger share of the market. For this reason, the diesel must now meet these qualifications:

1. Be suitable for installation in existing vehicles without major structural changes.
2. Match the gasoline engine in performance, size, and weight.
3. Have fuel consumption offset the higher installation costs within a reasonable mileage.
4. Have the lowest possible first cost.

These qualifications become more difficult to meet as the engine and vehicle size are reduced, but they are being met and the diesel has become a serious contender.

Installation problems

Diesel installation needs more attention. There have been too many poor conversions. Softer engine mounts are needed than for a gasoline engine and provision must be made for greater engine movement at low speeds. The diesel, particularly the direct-injection type, has an advantage over the gasoline engine in lower heat rejection, but this gain can be lost if there is inadequate clearance around the fan and restrictions in the release of the cooling air from the engine compartment.

Performance, size, and weight

Antechamber or indirect-injection combustion systems have been developed capable of smoke-free operation at high bmep's up to and above the speeds at which gasoline engines are rated, but which give specific fuel consumption 10% or more greater than open-chamber or direct-injection systems. The latter, however, have a top speed limitation around 3000 rpm in cylinder bores of 3.5–5.0 in. because of an inability to control the air movement in the cylinder over a greater speed range without some unacceptable sacrifice of fuel consumption or maximum torque at the lower speeds.

Indirect combustion systems have been developed which impose no practical limit on engine speed, excellent efficiency being possible up to 5000 rpm with a production engine. Furthermore, some modification is possible to allow the adaptation of the engine torque curve to suit the engine speed range required by a given application.

Diesel-engine size now compares well with the gasoline engine, but in weight it lags behind despite considerable reduction. As the pressure to reduce weight mounts in the future, introduction of light alloy engines will come in the smaller sizes.

Fuel consumption

The normal development of diesel usage is likely to lead to a world-wide shortage of diesel fuel if present specifications are maintained. Specifications must be changed to allow the economics of both engine and fuel to be as advantageous as possible while retaining the delicate balance of petroleum products.

Making the diesel omnivorous, or multifuel, has been suggested so that other existing fuels can be used but this type of engine would be more expensive and lose something in efficiency. All the advantages of the diesel engine can be maintained if a wider cut is allowed for the diesel fuel.

First cost

The diesel is inevitably more expensive than the gasoline engine, but costs can be lowered further. Larger production will justify tooling to bring down costs. Engineering and assembling the diesel as a line production job instead of a conversion would cut cost of modification. And, finally, use of modern manufacturing methods as fast as volume allows would help the situation.

To Order Paper No. 215A . . .
from which material for this article was drawn, see p. 6.

How to pick axle ratios

to match tire sizes in

Designing for

Based on paper by

W. M. Brown and Vaughn Dorsey

Kenworth Motor Truck Co.

HIGHWAY or off-highway mobility is a function of speed. And in this presentation of a method for calculating the proper overall ratio balance between tire revolutions and axle reduction, a speed of 35 mph is set as a maximum.

The method begins with the use of Table 1, which gives revolutions per mile for each tire size, and Fig. 1, which presents vehicle speed versus wheel rpm for various tires. Measured tire values are based on hard-surface conditions, as it is only in this area that various brands and tires of the same make can be correlated. From Table 1 and Fig. 1, one can determine the rpm any selected tire will turn at various speeds.

Table 2 gives the wheel rpm for different axle ratios with the engine speed 2100 rpm and the transmission in the top or highest gear. To the left of the chart is a series of overdrive ratios accumulating in the direct drive and one underdrive series. Across the top from left to right are different axle ratios. A heavy vertical line at the 11.56 ratio shows the maximum obtainable in the double-reduction type of drive.

Examples of method

Four examples are presented in Table 3. Example No. 1 determines the axle ratios which match the tires. Engine speed is 2100 rpm, the transmission ratio is 1/1 and the vehicle speed is to be 35 mph. On the front axle are 18.00 × 24 tires and on the rear 16.00 × 20. The revolutions per mile, obtained from Table 1, are 350 for the 18.00 × 24 tires and 402 for the 16.00 × 20 duals. From Fig. 1 we learn that 18.00 × 24 tires turn 207 rpm at 35 mph, while the

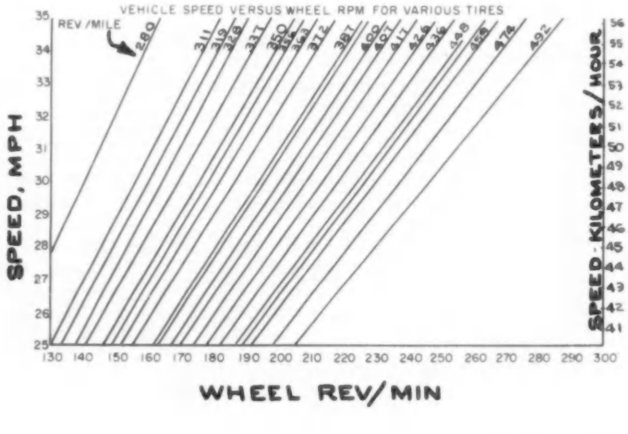


Fig. 1 — Vehicle speeds versus wheel revolutions per mile can be obtained from this chart.

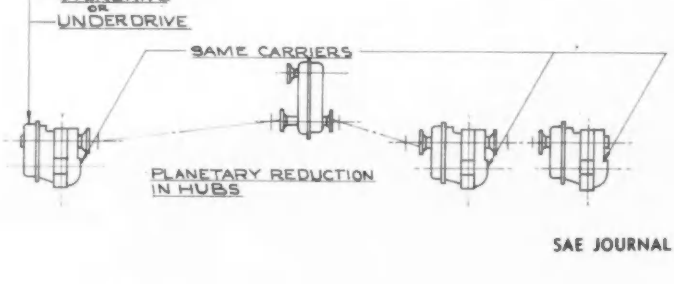


Fig. 2 — Proposed axle configuration with a ratio in the planetary hubs, a series of carrier ratios, and a series of overdrive ratios. Overdrive ratios can be inverted to have underdrive ratios.

off-highway truck mobility

Table 1 — Tire Data

Tire Size	Tread	Make	Type of Service & Revolutions Per Mile: Sand (Book)	Off-Highway (Book)	Highway (Book)	Measured Hard Surface
21 × 25	1	A		310		280 at 35 psi
	2	B		324		311 at 29 psi
	3	B	337			319
18 × 25	1	A		385		
	2	B		350		350 at 20 psi
	3	B	356			
18 × 24	1	A		385		
	2	B		352		
	3	B	363			
	3	C	387			
	3	D	390	372		
16 × 24	2	B		386		
	3	C	406			
16 × 20	1	A		406		402
	2	B		417		402
	3	B	409			
	3	C	436			402
	3	D	459	426	406	
14 × 20	2	B		453		
	3	B	474			
	3	D	492	468	448	
	1	A		425		
53-37-21	Special					400 at 20 psi
53-24-21	Special					407 at 20 psi
54-24-20.5	Special					407 at 20 psi

Table 2 — Wheel Rpm for Various Axle Ratios

Wheel Rpm for Different Axle Ratios with Engine at 2100 Rpm & Transmission in Top Gear

Over-drive Ratios	8.07	8.66	9.02	10.16	10.218	10.85	11.09	11.55	11.56	12.24	12.81	13.89	13.89	14.44	14.47	15.67	16.32	16.397	17.21	17.786	18.527	20.3	22.02	22.94
0.67	388	362	348	308	307	289	283	272	271	256	245	226	226	217	217	200	192	191	182	176	169	155	142	137
0.68	383	357	342	304	302	285	279	267	267	252	241	222	222	214	214	197	189	188	180	174	167	152	140	135
0.69	377	351	338	300	298	280	274	264	264	249	238	219	219	211	210	193	186	185	177	171	165	150	139	133
0.728	357	333	320	284	282	266	260	250	250	236	225	208	208	200	199	184	177	176	168	162	156	142	131	126
0.75	347	324	310	276	274	258	252	242	242	229	218	201	201	194	194	179	172	171	163	157	151	138	127	122
0.791	329	307	294	262	260	245	239	230	230	217	207	191	191	184	183	169	163	162	154	149	143	131	121	116
0.84	310	288	277	246	245	230	225	216	216	204	195	180	180	173	167	160	153	152	145	141	135	123	114	109
1.00	260	242	233	207	206	193	190	182	182	172	164	151	151	145	145	134	129	128	122	118	113	104	95	92
1.087	239	223	214	190	189	178	174	167	167	158	151	139	139	134	133	123	118	118	112	109	104	95	88	84

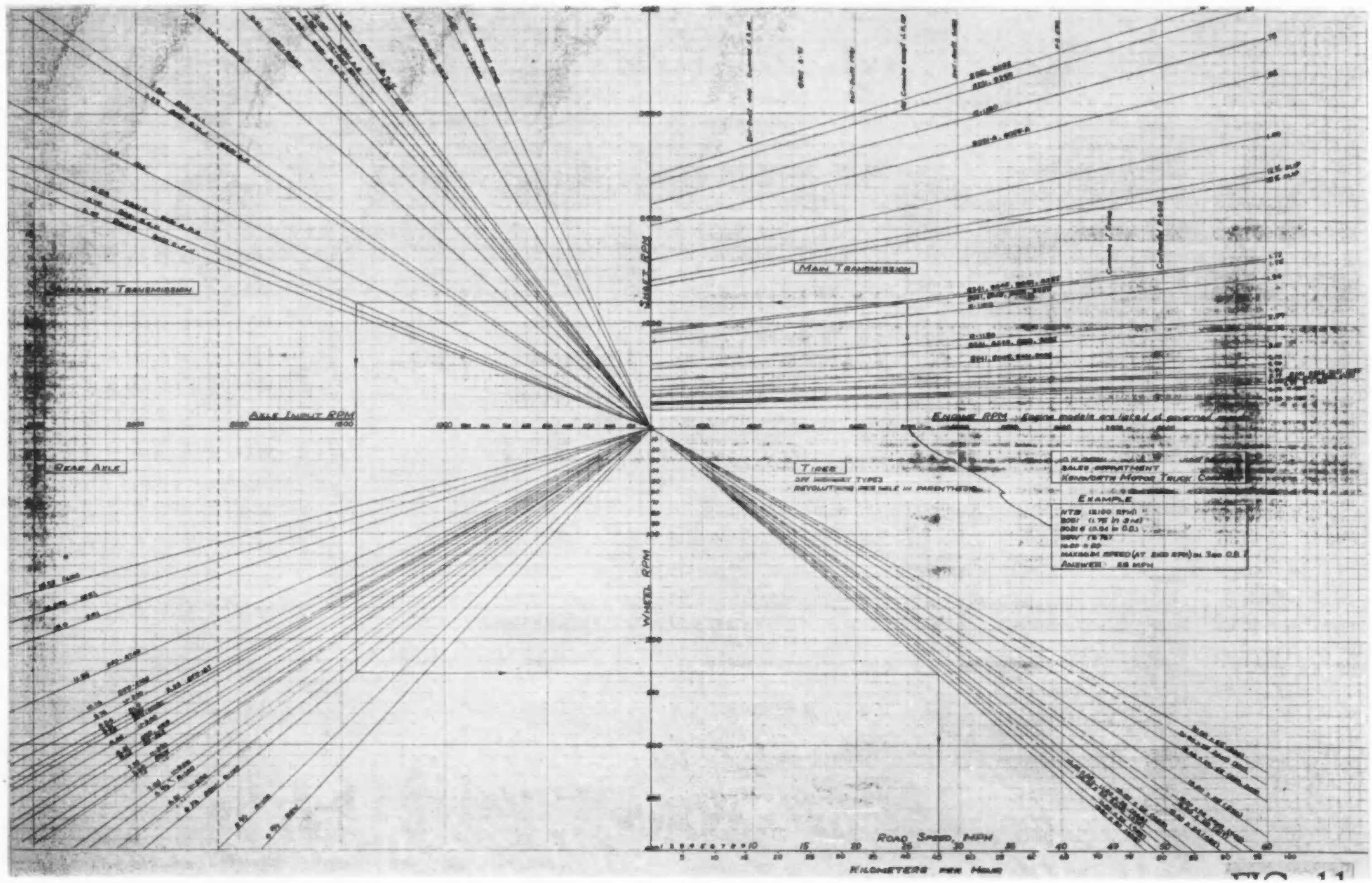


Fig. 4 — Data from all previous charts and tables are consolidated in this road speed chart (off-highway truck version). Simply follow a line around the graph counterclockwise to arrive at the required axle ratio.

Table 3 — How to Determine Axle Ratios to Match Tires of Given Size

1. Determine Axle Ratios to Match Following Tires:

	Front Axle		Rear Axle
Engine Speed = 2100 Rpm			Transmission Ratio = 1/1, $V = 35$ Mph
Tires	18 × 24		16 × 20 Duals
Rev/mile	350	(Table 1)	402
Rpm	207	(Fig. 1)	233
Axle Ratio	10.16	(Table 2)	9.02
2. Transmission Overdrive Ratio = 0.84			
Rev/min	207 at 35 mph	(Table 1)	233
Rpm	216	(Fig. 1)	230
Axle Ratio	11.56	(Table 2)	10.85
	$V = 35\left(\frac{216}{207}\right)$		$35\left(\frac{230}{233}\right)$
3. Transmission Overdrive Ratio = 0.67			
Tires	21 × 25		21 × 25
Rev/mile	311	(Table 1)	311
Rpm	182	(Fig. 1)	182
Axle Ratio	17.21	(Table 2)	17.21
	$V = 35$ mph		35 mph
4. Transmission Overdrive Ratio = 0.67			Mixed Tires
Tires	21 × 25		16 × 20 Duals
Rev/mile	311	(Table 1)	402
Rpm	182	(Fig. 1)	226 (233)
Axle Ratio	17.21	(Table 2)	13.89
	$V = 35$ mph		$35\left(\frac{226}{233}\right)$

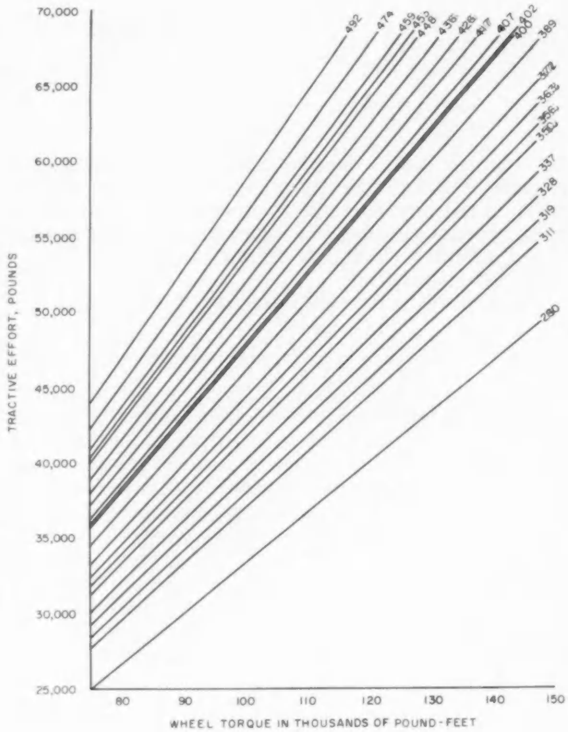


Fig. 3 — Tractive effort versus wheel torque for various values of tire revolutions per mile.

truck mobility

. . . continued

16.00 × 20's turn 233 rpm. Now refer to Table 2 and go down the left-hand column to the 1/1 ratio and across to 207. At the top of this column is the 10.16 axle ratio for the 18.00 × 24 tire. Farther along on the direct drive ratio of 1/1 we find that a 233 rpm for the 16.00 × 20 would give a rear-axle ratio of 9.02, which is a very good match with existing ratios used in the past.

In Example No. 2, using a transmission overdrive ratio of 0.84, the rpm at 35 mph (from Fig. 1) is again 207 for the 18.00 × 24 tires and 233 for the 16.00 × 20. Carrying these values to Table 2 for the 0.84 overdrive, 216 rpm provides the closest match for the 18.00 × 24's and 230 for the 16.00 ×20's. The front-axle ratio is 11.56/1, the rear axle ratio 10.85/1. The vehicle speed is 35 mph times the ratio of the rpm selected from Fig. 1 and used in Table 20. The mismatch is within the acceptable 2% error.

Example 3, given 21.00 × 25 tires and a transmission with a 0.67 overdrive, the rpm from Table 1 is 311 and (according to Fig. 1) the tire will be turning 182 rpm at 35 mph. Going to Table 2 across the vertical line until we reach 182, we learn that the needed rear axle ratio is 17.21/1.

In Example No. 4 we have a 0.67 overdrive transmission, 21.00 × 25 tires on the front and 16.00 × 20 duals on the rear. The revolutions per mile on the front are the same as they were before. The end ratio is 17/1. On the rear, 402 revolutions per mile will give 233 rpm at 35 mph. The nearest available ratio on this prognostication chart is 226, requiring a rear-axle ratio of 13.89/1. The front tire will be going 35 mph and the rear tire slightly slower. This is not a good situation, but it is within the acceptable error.

Other tires considered and measured to roll the same as the 16.00 × 20 and therefore requiring the same axle ratio as shown in Example 4 (Table 3) are 14 × 20, 18 × 25, 21 × 25, 24 × 20.5, and 37 ×21. This gives a general idea of the ratios needed, even as deep as 17.25/1.

An idea for obtaining deep ratios and still have proper vehicle speed for best mobility is shown by Table 4. Here three axles have the same carrier. The front axle is a drive-through type, which makes

truck mobility

. . . continued

an opposite hand carrier unnecessary. An added feature is the possibility of an overdrive or underdrive in the nose of each of these axles. This would be an opportune place to make some ratio changes. The planetary reduction in the hubs could also be adjusted if required.

Fig. 2 shows a proposed ratio family which includes a ratio of 3.50/1 in the planetary hubs, a series of carrier ratios and, in addition to them, a series of overdrive ratios. It is possible to invert these overdrive ratios and have a series of underdrive ratios. For instance, the planetary gearing listed and the 4.625 carrier will give four choices of axle ratios and be close to the desired 17/1 by changing only the drop gears. The 17.25/1 ratio mentioned earlier could be obtained by having a 6.50/1 carrier ratio and 0.75 overdrive gearing.

Table 4 — Proposed Ratio Family

Planetary	Carrier	Total Ratio 0.750	0.885	0.96	1.0
3.529	3.272	8.66	10.218	11.09	11.55
	4.10	10.85	12.81	13.89	14.47
	4.625	12.24	14.44	15.67	16.32
	5.25	13.895	16.397	17.786	18.527
	6.50	17.21	20.3	22.02	22.94

Tire tractive effort

A table of maximum torque available at the wheels for various transmissions and axles is presented as Table 5. The first example, with a transmission ratio of 4.4 in low gear, and axle ratio of 16.32, and the converter at stall, gives a wheel torque of 127,900 ft-lb. Carrying this value to Fig 3 makes possible selecting the proper value for the tractive effort of the various tires. The chart is based on a 0.6 coefficient of friction and the weight is from the proposed axle ratings.

All the data we've obtained by using several tables and graphs can be derived from Fig. 4 by simply chasing a line around the graph counterclockwise. This chart, like the others, has impossible ratios and other difficulties, but it give a basic figure needed for initial planning.

To Order Paper No. 213A . . .
from which material for this article was drawn, see p. 6.

Table 5 — Maximum Torque Available at Wheels for Various Transmissions & Axles

Engine: Gross Torque	Net Torque[a]	Corrected Torque (85% Efficiency)	Transmission: Converter + Transmission / Transmission + Auxiliary + Case	Ratio	Wheel Torque lb-ft, Axle Ratio 16.32	15.67	14.44	12.24
	2420	2060	Converter + Transmission	4.4	147,900	142,000	131,000	111,000
			Converter	4.0	135,000	129,000	119,000	101,000
			Transmission + Transmission	1.0				
			Converter Transmission	5.8				
935 at 1340rpm	842	716	Transmission Auxiliary Transfer Case	5.19 2.40 1.00	146,000	140,000	129,000	109,000
			Transmission Transfer	9.042 1.00	106,000	101,000	93,000	79,000
			Transmission Transfer	9.242 1.00	108,000	104,000	95,000	81,000
935	842	716	Transmission	9.98	117,000	112,000	103,000	87,000

[a] 90% of gross torque or converter output at maximum stall speed.

Brake failures

due to drum difficulties can be reduced

Based on paper by
Rolf W. Lange
American Brake Shoe Co.

CHANGES to prevent brake failures due to drum difficulties will aim especially to alleviate high drum wear and scoring, heat checking and cracking, and spotting.

High drum wear and scoring is sometimes associated with heavy duty linings having very high density and hardness, or those having high abrasive content for the normally desirable cleaning action against the drum.

Three steps will avoid such damage . . . and also damage resulting from a soft drum which lacks necessary wear-resistance to friction application . . . and damage resulting from drum surface temperatures in excess of 950 F or 1000 F. These steps are:

- Use a softer medium-duty lining (if a poor or soft drum is not involved).
- Use a good-quality gray cast-iron drum, or an alloy cast-iron drum.
- Get better heat dissipation through use of fans or blowers.

Heat-checking and cracking is generally due to very high temperature gradients. However, distortion, due to shoe pressure, probably contributes as well. When the drum and lining interface is alternately above and below 1330 F to 1400 F with each brake or clutch application, surface cracking can begin with the volume change which occurs on the phase-change of cast iron. Actually the surface element, which is heavily stressed due to the temperature gradient, is relieved somewhat by the smaller volume which it occupies above 1400 F. Between braking applications, however, the surface may cool below this transformation range, and expand while the underlying element is contracted. These cycles of stress produce the fine heat checks which can propagate and severely crack the drum.

It is not necessary to reach the 1330 F to 1400 F transformation temperature to induce cracking. Checking and cracking can occur through high drum temperature gradients alone, and is likely if the surface temperature is above 1000 F. In this case, the high stresses and the reduced strength of cast iron above 1000 F produce upsetting or failure in compression on the heating cycle. These failures are very evident when the drum surface cools and no longer covers its original area.

To reduce or solve drum heat checking and cracking problems, the following are suggested:

1. Use heavy-duty linings having a scrubbing or cleaning action. This actually increases drum wear, but the removal of the cast iron element containing the incipient cracking promotes longer drum life as a consequence.
2. Use a drum having an adequate amount of graphite in proper size and distributed as described previously.
3. Improve heat dissipation.
4. Use heavy-duty metallic linings with provisions for cooling the linings and drum.

Spotting results when small areas of drum surface are intensely overheated. The area may show signs of metal flow due to localized melting, or it may be heavily oxidized, or contain a stain from the lining. This condition is usually associated with high engagement speeds of a cold brake assembly. Spotting occurs when the heated drum surface expands rapidly and presents a wavy surface to the lining because the colder drum body has resisted expansion. A hard, wear resistant lining will not conform to this surface, and consequently engages the high spots. By so doing it contributes more heat to the overheated crests.

Drum spots become very hard if rapid cooling of the surface takes place. When heat checking occurs within the hardened spots, accelerated wear of the lining takes place because of the chisel-like nature of the drum surface.

Spotting may be avoided or corrected by:

1. A number of mild brake engagements which raise the temperature of the drum body prior to the high speed engagements. By doing this, there will be no cold metal present to "quench" the surface and the spots that do form are unlikely to be hard.
2. Use of soft resilient linings which will prevent or reduce drum spotting tendencies at the expense of lining life.
3. Use of a heavy-duty lining having the drum scrubbing properties which wipe away the element of overheated and damaged surface.

To Order Paper No. 224C . . .
from which material for this article was drawn, see p. 6.

Star Tracker

for

Interplanetary Vehicles

Based on paper by

Frederick Stevens

Nortronics Division Northrop Corp.

INTERPLANETARY travel will need optical navigation guides as space vehicles move out of the practical range of radio transmission. One of the keys to optical navigation is a precision star sensor.

The star fix gives one of the three basic elements in navigation, attitude. The other two are position and time. A star fix in conjunction with a planetary fix will give position, and extremely accurate atomic clocks (error of 1 part in 10^8) will supply the time.

A star senor and tracker, as shown in Fig. 1, should have the following characteristics:

- Adequate acquisition field.
- Small tracking field.
- High resolution after acquisition.
- No loss of central sensitivity.
- Practical size, power drain, and reliability.

In the design shown, these requirements are met by rotating the image of the star at a fixed frequency and then modulating this frequency to produce a tracking error signal. The FM light signal is picked up by a multiplier phototube and the resultant signal voltage is processed to give position and attitude information.

Star light enters the entrance aperture and is reflected into the objective by the diagonal scanning mirror. This mirror is mounted on a flexure post and is controlled by moving-coil permanent-magnet actuators to move the optical axis in a 28-min diameter circle for search or a 3.6-min diameter circle for track. The nutation frequency is 1 cps in each case.

The star light is imaged by a Cassegrain telescope, 20-in. efl and relative aperture F/20. The telescope is so proportioned and the optical path so folded that the package length of the telescope proper is only 2.4 in. The reticle in the focal plane consists of a centered pattern of eight pairs of sector-shaped elements alternately transparent and opaque.

The action of the nutating diagonal mirror in front of the objective causes the star image to trace a circular path over the fixed reticle. If the sight line is centered, the image trace is centered on the reticle and generates a constant frequency of 8 cps. If the sight line is decentered, the image circle is decentered likewise and the reticle modulates the beam with variable frequency. The magnitude of the misalignment is proportional to the frequency difference. The direction is disclosed by the phase.

The modulated light signal is picked by a multiplier phototube. This detector has a spectral distribution typical of the S-17 surface, the characteristics of which are shown in Fig. 2. This instrument is particularly sensitive to high-temperature stars, but the sensitivity with respect to all bright stars is adequate.

A field lens is provided behind the reticle which images the entrance pupil of the system onto the photoemissive surface; thus the system sensitivity is constant over the entire field of view.

Since direct sunlight would damage the device in its present form, a small sun sensor with somewhat wider field is mounted on the axis to produce a warning if the sun approaches the field of view of the star tracker. The sun signal energizes a shutter so as to occult the beam just in front of the phototube.

The star signal is amplified, limited, and demodulated at the nutation frequency. The error signal is then separated into x and y components. Because of the low frequencies used in the scanner, synchronous rectification is used in the comparator, using

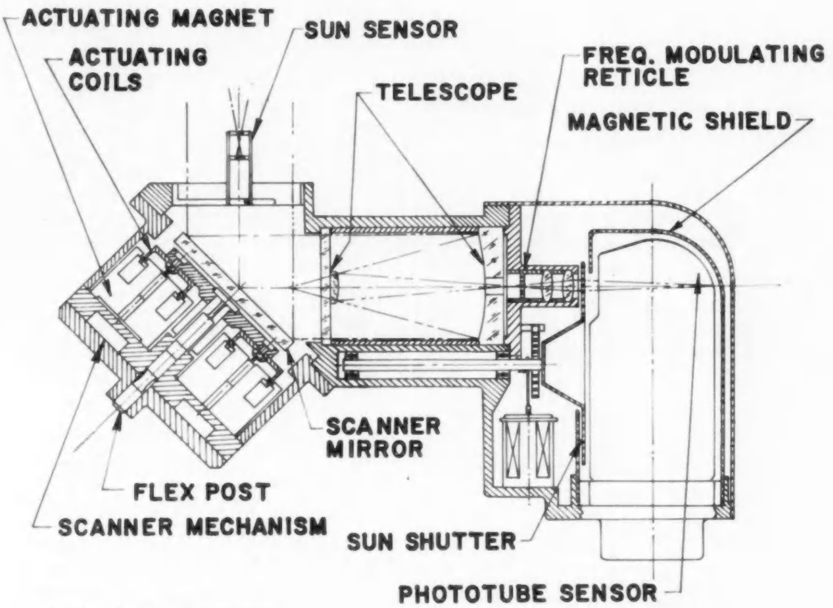


Fig. 1 — Precision star sensor.

phase information from the scanner driving signal.

The scanner mirror is driven from a power oscillator. The signal from the oscillator is phase-shifted, plus and minus 45 deg, introduced into a gain controller, then into the scanner driving coils. The search-track mode selector has two discrete gain control settings, which generate the proper size nutation circle for search and for track. The mode selector senses the signal from the limiter and the demodulator, and switches the scanner from the search to the track mode when there is a signal from the limiter, but not from the demodulator.

The use of this particular nutating scan technique in conjunction with the FM-type reticle has several important advantages:

- The system retains full sensitivity across the center of the field.
- The flexure post has a phenomenal operating life.
- Interchange between the wide field search mode and the narrow field.

The mechanical and electrical designs emphasize simplicity, low weight and bulk, reliability, and longevity. The power requirement for the scanner, the power supply, and the electronic circuits which process the signal is slightly less than 5 w. Longevity is assured by the use of the electromechanical scanning mechanism in which the moving parts are supported on a flexure post in lieu of rotating support elements. The mirror frequency (in flexure) is only one cps and the maximum displacement of the mirror is about 7 min (search mode) and 54 sec (track mode).

The design has been anaylzed and the following performance is obtainable:

Signal sensitivity, against 5th magnitude AO-type star	$S/N = 12$
Angle sensitivity search mode with 15% modulation	2.0 min
Angle sensitivity, track mode with 8% modulation	10 sec

This article is based on part of an Astronautic Symposium developed jointly by SAE and the Air Force Office of Scientific Research. The Symposium is available only as a book, titled "Vistas in Astronautics — 1960." To order, turn to p. 6.

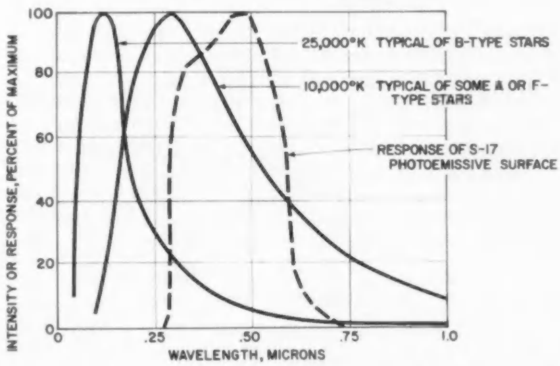


Fig. 2 — Comparison of high-temperature stars and S-17 photomissive detector.

Corrugate construction reduces vehicle weight

Based on paper by

H. V. Parsley and L. L. Lemke

International Harvester Co.

OFF-HIGHWAY vehicles can be made lighter by using corrugations that permit metal section thickness to be decreased without loss of strength. The practice has been applied to truck pan guards, canopies, and dump bodies with notable success. The result is an increase in payload without the cost increase such as is incurred when weight reduction is sought through the use of aluminum.

By substituting a one-piece corrugated pan guard for the customary two-piece flat unit and running it from the bumper to the rear support in back of the transmission (Fig. 1), a weight saving of 300 lb has been obtained. Some of the saving comes from the use of a single piece, but the bulk of it is due to the corrugations. Moreover, the lighter weight guard is easier to handle when it has to be dropped for work on the engine or transmission.

Corrugated canopies

Canopies on quarry dump bodies are intended to protect the driver from falling rock, but on occasion they are misused for load carrying. Accordingly inverted angles have been welded to the canopy to provide stiffness to the flat area. Here the use of corrugations and elimination of inverted angles has decreased the weight per foot by 32% and increased the section moduli by 33%. There is also a cost saving through elimination of welding. A comparison of canopy cross-sections is shown in Fig. 2.

Dump body construction

The application of corrugations to a dump body is shown in Fig. 3. The body is a box which must withstand falling rock, bouncing at high speed, and include some method for load removal. The sides are corrugated and take the resultant of the side load and the vertical pressure load, which are transmitted to the side bolsters. The maximum side pressure occurs on the side corrugations at the lower edge.

The weight saving is readily apparent since less steel is required to obtain the same section moduli as the flat plate. Corrugated side panels also save weight by eliminating some side bolsters because stronger sides permit greater spans between bolsters.

The floor takes the worst beating; it must sustain rock falling from as high as 8 ft above it. Here, again, corrugated construction permits the use of thinner material without loss of strength and corresponding body life. Loading diagrams for the body floor are shown in Fig. 4 and illustrate how the combination of the edge span load and the center span load results in the maximum floor bending moment at the main frame section. To balance the higher moments at the two reaction areas, wide flange beams supporting the floor provide increased section, which results in a more uniformly stressed floor.

Facility for heating

The corrugated floor provides excellent passages for the exhaust gases from the engine which are used to warm the floor to facilitate dumping. There is a very low back pressure and a very even heat over the floor. In the past, ship channel has been substituted for certain portions of the oak flooring to provide passages for the exhaust gas. It had to be manufactured especially and could not be an attachment.

Corrugated construction of a body of conventional design has brought the weight down to 15,400 lb for a 24-ton capacity truck (16 cu yd struck capacity), while new corrugated bodies for a 27-ton capacity truck (18 cu yd capacity) weigh 12,300 lb.

To Order Paper No. 216A . . .
from which material for this article was drawn, see p. 6.

Fig. 1 — One-piece, corrugated pan guard to protect engine and transmission is 300 lb lighter than orthodox two-piece, flat plate guard.

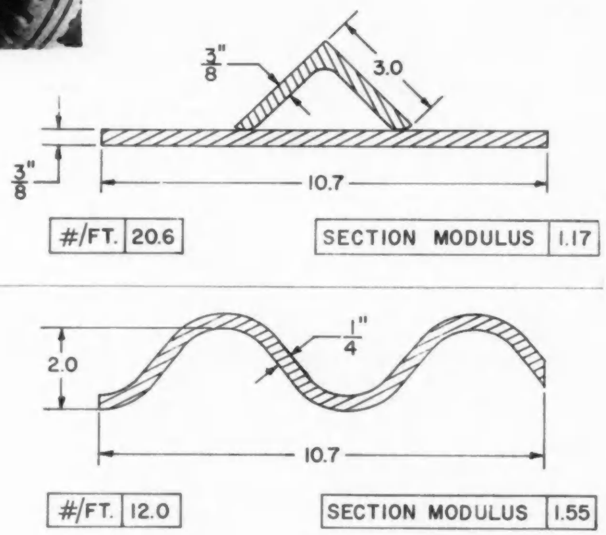


Fig. 2 — Merit of corrugated canopy shown by comparison with canopy formed by welding angles to flat plate.

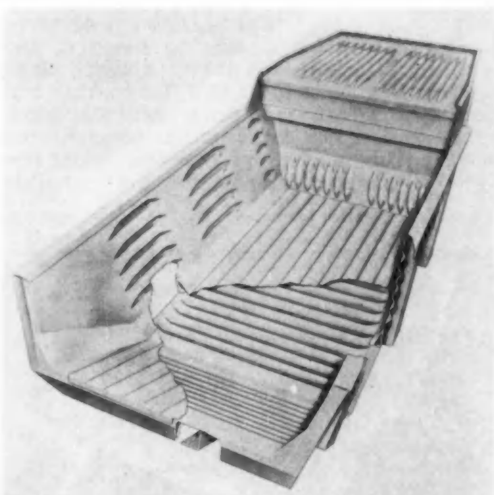


Fig. 3. — Cutaway of dump truck body showing corrugated construction of sides, floor, and canopy. Exhaust gases are easily circulated through passages in floor to facilitate unloading.

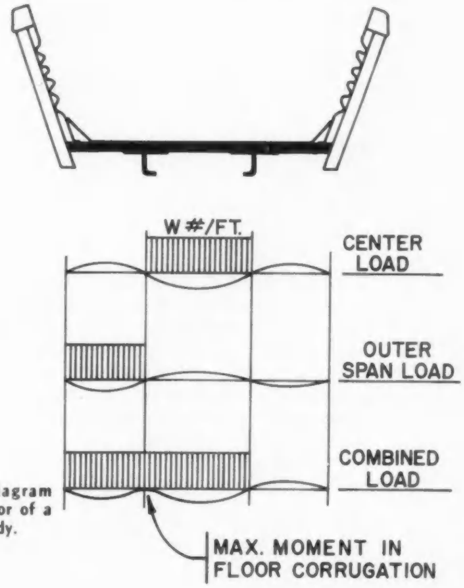


Fig. 4 — Loading diagram of the corrugated floor of a quarry dump truck body.

A new graphical way to simplify bearing

Based on paper by

H. B. Scheifele

Federal-Mogul-Bower Bearing, Inc.

A SIMPLIFIED, graphical, bearing life analysis has been devised, to replace the complex analysis otherwise involved, for gear trains receiving their power from torque converters. The use of a torque converter complicates the bearing analysis, because the high torque rise possible with such a device necessitates the analysis of the complete spread of converter output, and not just an arbitrary torque condition. Where torque converters are not used in the power train, rated engine input is the basis of the analysis, and calculation of bearing life is straightforward and accurate.

The graphical analysis is as simple as running the standard type of bearing calculation on a power train without a torque converter. The development of only one bearing life curve on log-log graph paper is all that is necessary to analyze every bearing in the gear train for any speed ratio.

Development of the analysis

Functioning of the method can be illustrated using the typical earthmoving vehicle gear train arrangement shown in Fig. 1. Here, 50% of the converter output torque is delivered to this train, which represents one side of the final drive.

The general equation for bearing life is:

$$\text{bearing life} = \left[\frac{\text{bearing rating}}{\text{bearing load}}\right]^{3.33} \times \frac{500 \times 3000}{\text{bearing rpm}}$$

An expression for the life of bearing c in terms of converter output torque Q, bearing speed n, and bearing rating R, is developed in Figs. 2 and 3. Here, it is seen that bearing load = 2.42 Q, for bearing c in first speed forward. Since, for any particular speed ratio configuration, converter output rpm, bearing speed, and vehicle speed are proportional to one another, the bearing rpm term in the "life" equation

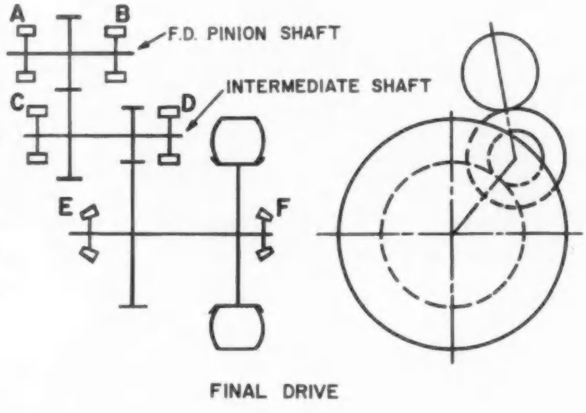


Fig. 1 — **HALF THE POWER** of the torque converter is used to drive the gear train. Analysis of all the bearings in the gear train, for any speed ratio, is possible by developing a log-log plot of bearing life versus vehicle speed for any one bearing at one speed ratio. Bearing c is the one chosen here.

life analysis

Glossary of abbreviations

K = Vehicle constant for first speed forward

$L_{c\text{-}1f}$ = Hours life of bearing c in first speed forward. Subscripts are explained as follows: c = gear in question, 1 indicates speed, and f = forward

N = Converter output rpm

Q = Converter output torque

P_2 = Tangential load on gear 2. Subscript identifies gear

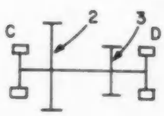
R = Bearing rating at 500 rpm and 3000 hr B-10 life basis

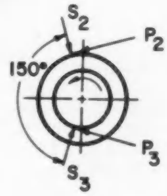
$R_{c\text{-}1f}$ = Load on c bearing in first speed forward. Subscripts have the same meaning as above

S_2 = Radial load on gear 2. Subscript identifies gear

n = rpm of bearing

INTERMEDIATE SHAFT





1ST FWD TRANS. RED. = 2.50

BEVEL GEAR RED. = 4.40

TORQUE 1ST FORWARD

$$.50 \times Q \times 2.5 \times 4.4 \times \frac{30}{15} = 11.0\ Q$$

GEAR DATA

NO.	T	PITCH	P.D.	PRESS∠
1	15	3	5.0	20°
2	30	3	10.0	20°
3	10	2	5.0	20°

GEAR FORCES

$$P_2 = 11.0 \times Q \times \frac{2}{10} = 2.2\ Q \qquad P_3 = 2.2 \times Q \times \frac{10}{5} = 4.4\ Q$$

$$S_2 = 2.2 \times Q \times \tan 20° = .8\ Q \qquad S_3 = 4.4 \times Q \times \tan 20° = 1.6\ Q$$

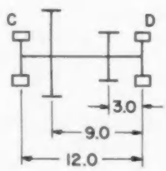
Fig. 2 — **TORQUE ON THE INTERMEDIATE SHAFT** is calculated from the given data, bearing in mind that half the output Q, of the torque converter, is applied to the gear train, and that a reduction in speed by any factor involves an increase in torque by that same factor. Thus a 2/1 decrease in speed from gear 1 to 2 increases the torque on the shaft by a factor of 2. The same holds true for the given speed reductions.

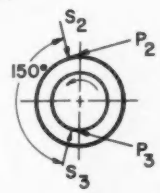
Tangential forces on the intermediate shaft gears are found by the relationship: torque = force x radius. The radial forces are found by noting that the resultant force on the gear teeth acts at a pressure angle of 20 deg.

Fig. 3 — **LOAD ON BEARING c IS CALCULATED** from the gear forces, previously determined, by taking moments about the point where the shaft pierces the plane of bearing d. All forces are resolved along the directions of P_2 and S_2 and the resultant bending moment is calculated, from which the bearing load, $R_{c\text{-}1f}$, is found to be 2.42Q. The value of $R_{d\text{-}1f}$ is similarly found to be equal to 3.75Q.

The speed of the intermediate shaft is found by dividing the output rpm of the torque converter by the product of the three speed reduction factors of Fig. 2. Values of load and bearing speed are then inserted into the bearing life equation to obtain points for a bearing life curve.

INTERMEDIATE SHAFT





BEARING LOAD - 1ST FWD

$$R_C = \left[\left(2.2\,Q\,\frac{9}{12} - 1.6\,Q \sin 30°\,\frac{3}{12} + 4.4\,Q \cos 30°\,\frac{3}{12}\right)^2 + \left(.8\,Q\,\frac{9}{12} - 1.6\,Q \cos 30°\,\frac{3}{12} - 4.4\,Q \sin 30°\,\frac{3}{12}\right)^2\right]^{\frac{1}{2}}$$

$$R_{C\text{-}1F} = 2.42\ Q \qquad RPM_{C\,\&\,D} = \frac{\text{CONVERTER RPM}}{22.0}$$

ALSO $R_{D\text{-}1F} = 3.75\ Q$

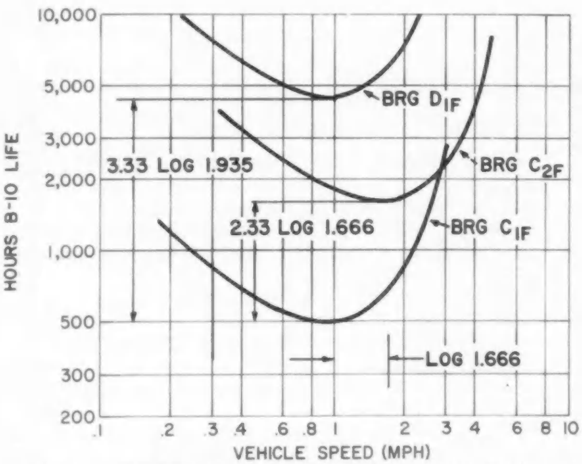


Fig. 4 — **BEARING LIFE OF GEAR** *c* in first and second forward speed ratios, and of gear *d* in first, plotted on log-log coordinates. The shapes of all the curves are the same, only the placement varies.

Simplify bearing life analysis

. . . continued

can be replaced by the corresponding vehicle speed.

With this information a log-log plot of bearing life versus vehicle speed may be drawn as in Fig. 4. The curve for bearing c in first forward is labeled "BRG C_{1f}."

This curve may be used to obtain the bearing life curves for all of the bearings involved, in any speed ratio, according to the method given in Figs. 5 and 6.

To Order Paper No. 227A . . .
from which material for this article was drawn, see p. 6.

$$(AB)^X = A^X \cdot B^X \qquad \frac{A^X}{A^Y} = A^{X-Y}$$

$$\text{TORQUE RATIO} = \frac{\text{2ND}}{\text{1ST}} = \frac{1.50}{2.50} = .60$$

$$L_{C\text{-}2F} = \left(\frac{R}{2.42\,Q \times .6}\right)^{3.33} \times \frac{500}{\frac{n}{.60}} \times 3000$$

EXPRESSED AS:

$$L_{C\text{-}2F} = \left(\frac{R}{2.42\,Q}\right)^{3.33} \times \frac{500}{n} \times 3000 \times \left(\frac{1}{.60}\right)^{3.33} \times \frac{.60}{1}$$

$$L_{C\text{-}2F} = L_{C\text{-}1F} \times .6^{-2.33} \quad \text{OR} \quad L_{C\text{-}1F} \times 1.666^{2.33}$$

$$MPH_{2F} = 1.666\ KN \quad \text{OR} \quad 1.666\ MPH_{1F}$$

Fig. 5 — **WHEN CHANGING FROM FIRST TO SECOND,** the torque on the intermediate shaft and the bearing speed are both changed by a factor of 0.60. Using the laws of exponents, given at the top, the life of bearing c in second is shown to be equal to the life in first — multiplied by the constant $1.666^{2.33}$.

The vehicle speed in second changes in the same proportion as bearing speed and is, therefore, equal to the vehicle speed in first times a constant. The vehicle speed in first is equal to converter output rpm *N*, multiplied by a vehicle constant *K*, for first speed forward.

$$\text{LOG}_a (MN) = \text{LOG}_a M + \text{LOG}_a N$$

$$\text{LOG}_a O^P = P\ \text{LOG}_a O$$

$$\text{LOG}_a \frac{M}{N} = \text{LOG}_a M - \text{LOG}_a N$$

THEREFORE

$$\text{LOG } L_{C\text{-}2F} = \text{LOG } L_{C\text{-}1F} + 2.33 \text{ LOG } 1.666$$

$$\text{LOG } MPH_{2F} = \text{LOG } MPH_{1F} + \text{LOG } 1.666$$

SIMILARLY

$$\frac{R_{D\text{-}1F}}{R_{C\text{-}1F}} = \frac{3.75\,Q}{2.42\,Q} = 1.55 \qquad \text{LET BRG "D" RATING} = 3R$$

$$L_{D\text{-}1F} = \left(\frac{3R}{1.55 \times 2.42\,Q}\right)^{3.33} \times \frac{500}{n} \times 3000 \quad \text{OR} \quad \left(\frac{3}{1.55}\right)^{3.33} \times L_{C\text{-}1F}$$

$$\text{LOG } L_{D\text{-}1F} = 3.33 \text{ LOG } 1.935 + \text{LOG } L_{C\text{-}1F}$$

Fig. 6 — **TO CONVERT THE LOG-LOG PLOT** of the life curve of bearing *c* in first to a curve for the life in second, it is only necessary to add a constant amount to each ordinate of the original curve (note the laws of logarithms at the top). Likewise each abscissa of the original curve is increased by adding a constant, to give the abscissas of the new curve. The new curve, representing the life of bearing *c* in second, is thus obtained by shifting the original curve upward and to the right by fixed amounts. The results of this maneuver are shown in Fig. 6. The new curve is labeled "BRG C_{2f}."

If it is desired to plot a life curve for bearing *d* in first, it is necessary to change the load by the appropriate factor (1.55) and take into account any changes in bearing rating. It is evident that the life curve for bearing *d* in first is obtained by shifting the curve BRG C_{1f} upward by a fixed amount. No horizontal shift occurs because the gear train is still in first.

To find the life of bearing *d* in second, the same procedure as was used for bearing *c*, above, is employed.

Briefs of SAE PAPERS

Continued from page 6

mit optimum selection of system; block diagram shows combinations required to be compatible wtih weapon system; component characteristics of auxiliary power comprising source of energy, prime mover and means of conversion of power to electric or control power (hydraulic) generation; component parameters.

How to Select Power Systems for Aero-Space Applications, J. S. NEWTON. Paper No. 223D. Term covers all systems of equipment for generation, conversion, transmission, and use of power or energy in any form; paper deals with auxiliary power systems; types of classification; basic requirements, using rotary electric generator drive, and boundary layer air compressor as example; state of art surveys, determination of quantitative relationships between technical and economic factors, preparation and use of specifications; list of 23 basic questions.

Mach 3 Wing Structures Stiffened Skin Versus Sandwich, J. C. JOANIDES, S. C. MELLIN, L. M. LACKMAN. Paper No. 233D. Study made at North American Aviation, Inc.; wing structure weight plus insulation is computed for delta-winged aircraft cruising at 70,000 ft, thermal stability limits of JP-6 fuel being such that they require thermal protection from aerodynamic heating; spanwise and chordwise bending, transverse and torsional shear, and internal pressure loadings are considered; integrally stiffened wings, using AM-355 steel, all-beta titanium alloy, and beryllium, are compared with PH15-7Mo steel brazed honeycomb sandwich wing.

Missile and Space Vehicle Non-Propulsive Power Concepts, D. K. BREAUX, W. L. BURRISS, R. L. SCHULTZ. Paper No. 234A. Mission requirements of systems providing internal power for guidance, control, communications, etc.; energy sources and conversion equipment; propellant selection; possible prime movers considered are multistage turbine and piston type positive displacement engine; details of hydrogen-oxygen Integrated Power and Environmental Control System (IPECS) including turbine gearbox assembly, alternator, hydraulic pump, heat exchangers, circulating fan and controls.

Power Generating Systems for Manned Space Vehicles, W. C. DUNN. Paper No. 234B. Evaluation of general characteristics, and practical limitations of several types of space power generating systems including solar direct conversion, nuclear mechanical rotating, and regenerative fuel cells; concepts involved in choice of equipments for rotating conversion machinery; materials of construction and possible choices of working fluids for conversion equipment; hypothetical power generating system and criteria employed in design of system.

Secondary Power Systems for Space Vehicles, D. B. MACKAY. Paper No. 234C. Study at North American Aviation, Inc., of Rankine cycle for power generators analyzing effects on cycle operations of pertinent physical properties of fluids; cycle efficiency of liquid metals found considerably higher than that of nonmetals; charts for use in preliminary design facilitate efficiency calculations and comparison of cycles and fluids; comparison between power cycles using mercury, rubidium, cesium, potassium, and sodium shows promise for rubidium cycle if turbine inlet temperature is above 1600 R.

Reliability Implementation in Engineering Design, I. DOSHAY. Paper No. 235A. Paper illustrates techniques of data development through statistical reduction methods to rocket propulsion system reliability; analysis of failure trends and formulation of derating stress factors; application of reliability relationships through engineering techniques and assurance of reliable design through design review; mathematical demonstration of applicability of exponential approximation to case of constant hazard shown in appendix.

Integrated Reliability and Maintainability Program, M. E. WHEELOCK. Paper No. 235B. Program developed for F-108 and B-70 Weapon System Programs of aircraft or missile performance by Los Angeles Div. of American Aviation; consequence of changes in equipment reliability and maintainability on total effectveness is shown; these parameters are related to certain other parameters and their interactions presented; methods of predicting and controlling them show how program can be carried through.

Reliability Factors in Part Procurement, D. C. BEERY. Paper No. 235C. Procurement of reliable parts in aircraft or missiles is problem of determining characteristics part must meet, and communication of these to buyer, manufacturer, and acceptance inspector; factors that can influence method for specifying reliability of part such as use of failure rate, and determining part acceptability by specification of minimum failure rate adn measurement methods, or by strengthening of critical failure modes through control of materials, process methods or characteristics.

Role of Reliability Field Engineering Program in Weapon Systems Reliability, C. A. OVERBEY. Paper No. 235D. Method of operation of Convair Astronautics' Reliability Field Engineering Program for Atlas missile and summary of specific benefits to be derived; recommendations made for companies that desire to set up similar programs with respect to direction and control, selection of personnel, plant support, feedback to field, etc.

Shock Testing with Electrodynamic Shaker, R. H. WELLS, R. C. MAUER. Paper No. 236A. Lockheed shaker system is used to perform transient dynamic response tests on T2V-1 Sea-Star Naval training aircraft to obtain substantiation of calculated landing loads; system consists of four air-cooled shakers and three electronic power amplifiers and operates in frequency range of 0–500 cps; types of pulse generators are photoformer, wave shaper, and gating circuit; typical tests performed.

Representing Frequency Response Characteristics of Elastomers for Shock Isolation, R. E. NEWTON, L. E. MATTHEWS. Paper No. 236B. Shock isolator is idealized as spring and dashpot in parallel; improved model for elastomers results from using dashpots, each in series with spring, in place of separate dashpot; quantitative characteristics of improved model are deduced; model derived for rubber sample; behavior compared with that of rubber; shock response of new model is compared with conventional one.

Flight Characteristics of DC-8, O. R. DUNN. Paper No. 237A. Development history of Douglas transport which is result of 10 yr of design effort, involving detail design, construction, and flight testing; fail-safe design concept; wing design and method used to solve tip stall problem; wing is defined by three airfoil sections and has desired high drag divergence Mach number, good maximum lift capability, and stall characteristics; horizontal tail, vertical surface, and lateral controls; recent design developments.

Flight Testing Convair 880, D. GERMERAAD. Paper No. 237B. Medium range jet airliner is built to operate from today's airports without need for extra-length runways, with maximum range of 3000 m; maximum normal operating Mach number is .89; human factor considerations coupled with veteran pilot inputs dictated location of all controls, switches, instruments and alerting systems ensuring basic flight safety; flight controls and flight char-

Continued on page 92

Briefs of SAE PAPERS

Continued from page 91

acteristics; General Electric CJ805-3 engine performance; emergency operation, and flight testing.

Community Psychoacoustics — Key to Aircraft Noise Design and Operation, B. SPANO. Paper No. 238B. Introducing aircraft operations into community and exposing it to maximum noise can cause serious agitation; community reaction is shown in chart as listening learning or familiarization curve; approach of using scientific introductory noise control measures in flight and ground operation to reduce noise complaint motivation; three steps in determining maximum noise level and developing procedure known as Complaint Motivation System.

System Approach to Reduced Air Cargo Costs, L. B. ASCHENBECK. Paper No. 239C. Basic elements of air cargo system are modern inventory control, packaging and shipment techniques, rapid transit from manufacturer or distribution point to airport, modernized terminal handling, and jet cargo aircraft; requirements of each element and steps to take.

Design and Development History of J79 Engine, F. L. SMITH, N. BURGESS. Paper No. 240A. General Electric J79 afterburning turbojet engine capable of level flight speeds in excess of Mach 2.0 at and above 35,000 ft, has specific fuel consumption of 0.78 lb of fuel per lb of thrust per hr; basis for selection of J79 cycle; comparison with earlier General Electric engines; component design philosophy and description with respect to compressor, combustion, turbine, afterburner, accessory and control section; main fuel system and its operation; performance data.

Development of Pyrophoric Fuel Thrust Augmenter for J69 Engine, D. G. BAY, J. H. HILL. Paper No. 240B. Afterburner, developed by Continental Aviation, to improve performance of target drone aircraft uses mixture of triethylaluminum and trimethylaluminum to permit operation at combustion velocities considerably higher than those encountered in regular JP-4 afterburners; properties of fuels selected; nozzle ejection system and ignition; details of drone fuel system consisting of fuel tank, nitrogen bottle, fuel control and sequencing control; safety features.

Design Characteristics Affecting Gas Turbine Combustion Performance, A. H. LEFEBVRE, T. DURRANT. Paper No. 240C. Study made by Rolls-Royce, Ltd. to examine influence of fuel type on exhaust smoke, liner temperatures and aspects of combustion; properties of three grades of kerosene employed, one of which (T F 4319) was developed to reduce exhaust smoke and metal temperatures; design variables; tests confirmed advantages claimed for lighter kerosenes in terms of reduced smoke, easier ignition and higher combustion efficiency at extreme altitudes.

Silo Lift Launcher System for Atlas ICBM, R. H. THOMAS. Paper No. 241A. Silo concept, developed by Convair-Astronautics consists of underground cylindrical encasement in which missile is maintained and protected in vertical attitude; silo consists of concrete lined hole 52 ft ID × 174 ft deep; underground tunnel connects silo to launch control center; details of ground support equipment comprising suspension systems, lift and hydraulic system, sequence control, and missile emplacement system.

New Concept in Ground Movement, R. F. ADICKES. Paper No. 241B. Pilot Tug, multi-purpose vehicle, developed by American Machine Co., to provide ground power requirements for jet aircraft and to move on ground; unit combines adaptability for wheel moving, jet engine starting, auxiliary electric power, versatility, safety, maneuverability, and speed, and eliminates taxiing operations.

Automatic Checkout Equipment — Airline Viewpoint, J. A. ALDRICH. Paper No. 241C. United Air Lines outlines what typical airline wants in way of automatic check-out equipment, progress made to date and appeals for earlier planning so that equipment can be employed to greater extent; maintenance activities comprise line maintenance and aircraft overhaul, each of which calls for different equipment; semi-automatic checkout equipment, used by airline for DC-8 autopilot system accomplishes 99 tests, and pinpoints component to be replaced; checkout equipment being developed for main a-c generating system; general principles.

Voice Frequency Communicaton System for Operational Missile Weapon Systems, R. R. DYE. Paper No. 241D. Steps in design of system for complex long range guided missile weapon system; use of six channels capable of serving 30 man crew simultaneously; details of important parameters: magnitude and spectrum level of ambient noise in frequency band of 200 to 6000 cps; characteristics of microphones and headsets; magnitude and spectrum level of various noise sources; characteristics of speech channel, including gain, frequency response, AGC, and peak clipping.

H-1 Rocket Engine for Saturn, R. HEALY. Paper No. 242A. SATURN project and development of rocket booster by Rocketdyne, having thrust uprating of 188,000 lb to develop 8-engine cluster thrust of over 1.5 million lb; propellant combination is liquid oxygen and RP-1; H-1 Model employs thrust chamber, turbopump assembly, gas generator system, and control valves developed in IRBM and ICBM programs; thrust buildup characteristics; thrust chamber assembly; engine control; clustering effects; feasibility study of recovering booster after flight under way.

Fire Safety Design Considerations for Rocket Powered Vehicles, K. P. LOPP. Paper No. 242D. Need for scientific research of hazard criteria with respect to propellants, characteristics of exotic fuels and fluids, and types of sources which may serve to ignite combustible leakage; hazard analysis taking into account fire probability during captive flight, launch and firing, ballistic trajectory, re-entry, and deceleration and landing regime; fire prevention by means of compartmentation, sealing, drainage, equipment design and installation; fire protection.

Some Comments on Selection of Rocket Nozzle Expansion Ratios, F. G. ETHERIDGE. Paper No. 242E. Study concentrates on two parameters most amendable to analytical approach, performance and weight; remarks and examples are slanted toward liquid propellant, equations are general and apply equally to solid propellant engine; booster trajectory analysis will yield optimum altitude, and therefore ambient pressure, for which nozzle should be designed; pertinent equations.

Applications of Army-Navy Instrumentation Program to Transport Aircraft, A. M. MAYO, H. L. WOLBERS. Paper No. 243A. Outline of ANIP Program emphasizing human factors area; research made of way in which man visualizes data, man-machine system, display of information, and requirements of system including display devices, computers, controls and sensors; examples of developments, such as gyro developed for program by Minneapolis-Honeywell, control computer, RV-2 computer concept, transparent cathode ray tubes, etc.

Loctracs — All Aircraft Surveillance System, P. F. PEARCE. Paper No. 243B. System is designed by Lockheed Electronics Co. to furnish complete data on all of aircraft in area to ground controller; each aircraft in LOCTRACS system carries pulse-coded transmitter operating together with ground network of receiving stations; four ground stations define sector of coverage; signals received at sites are relayed by

microwave links or telephone lines to surveillance center, where information processing takes place; principles of operation; block diagram.

Atmospheric Density as Altitude Indicator, H. E. REIQUAM. Paper No. 243C. Atmospheric errors in altimeter system arise from fluctuations in measured parameters, manifested as not indicated altitude variations; analysis reveals that at low altitudes in troposphere, density altitude is less accurate than pressure-altitude; above about 15,000 ft, either pressure or density is acceptable altitude determinant; device developed for measuring density more accurately than pressure altimeters measure pressure; possibility of combining two systems should be examined.

Lockheed BLC Hercules — Practical STOL Transport, F. N. DICKERMAN and C. F. BRANSON. Paper No. S259. Development program for C-130 Hercules airplane, which has complete blowing boundary layer control. Studies of various blc systems, preliminary analyses of previous tests, wind-tunnel program, simple flight simulator, and flight test program, directed toward demonstration of airplane's performance.

Combination Engine Starter and Constant-Speed Drive, F. R. CORDON and D. J. HUCKER. Paper No. S268. Discusses the problems of combining electrical engine starting capability with aircraft generating system, and describes one particular hydrostatic transmission arrangement evolved to perform this function. Covers: starting characteristics of gas turbine engines, motor performance capabilities of modern aircraft generators, hydrostatic transmission, details of electrical system and associated controls.

GROUND VEHICLES

Principles of Replaceable Absorbent Filter Cartridges, H. A. WILSON. Paper No. 223A. Use of "absorbent" filter media on hydraulic oils in mobile equipment; filtration specifications for optimum operation; use of natural and synthetic cellulose fibers in processed forms as media for depth cartridges; techniques to establish element performance data are: determination of particle-size ratings and development of data enabling selection of appropriately sized filter, considering differential pressure loss, flow, viscosity, and degree of clarity.

Surface Type Hydraulic Filters, H. L. FORMAN, C. J. CASALEGGI. Paper No. 223B. Reinforced paper surface and edge type filters used as fluid cleaning device are charaterized by fact that contamination particles are retained on surface of filter with some entrapment occurring below surface; how filter is rated or evaluated; bubble point test to measure effective pore in surface filter medium, and relationship between initial bubble point and effective pore size of several media; test stands and procedure used at Purolator Products, Inc., Rahway, N. J., for determination of filter life; effect of pore sizes on capacity; review of various filter sizes, capacities and types.

Mobile Hydraulic Systems Filtration, L. E. TERRY. Paper No. 223C. Need for filtration is stressed and concepts of filtration are outlined; of three principles of filtration, i.e., mechanical, adsorption, and magnetic filtration, first one is considered by far most important; examples of filter applications and description of some installations by various manufacturers.

Excavator Clutches and Brakes — Basic Properties of Friction Materials, A. J. BETTE. Paper No. 224B. Composition of organic friction materials, binders and additives to enhance strength and to stabilize friction; by achieving proper balance in various elements of formula various degrees of friction level, temperature resistance, and rates of wear are obtained; mechanisms employed to measure properties of materials; behavior and selection of materials and choice of friction coefficient which depends upon published rating of given material, adjusted for extreme factors expected to occur.

Stylist: Engineer-Stylist Relationship, R. TEN EYCK. Paper No. 226A. General discussion examining functions of two departments shows that cooperative effort from both engineer and stylist, and honest respect by each for specific problems and objectives of other is needed to develop successful models in machinery and equipment; effectiveness of styling is in direct proportion to degree of interest and cooperation received from engineers.

Engineer: Engineer-Stylist Relationship, R. ADEE. Paper No. 226B. General discussion of departmental relationships involved in designing various models of self propelled windrowers, straw chopper attachment, and other crop equipment; while restyling has resulted in increased costs, these were offset by increasing sales and prestige; additional cost of Industrial Design appears to be justified and will be continued.

Styling and Functional Aspects of Utilizing Reinforced Polyester Resin in Fertilizer Distribution Equipment, M. C. CHRISTENSEN. Paper No. 226C. Problems of corrosion encountered which reduce life of equipment and metering accuracy; development of fertilizer hopper for planter and cultivator attachments by Ford Co., using agitator over orifice metering mechanism with sliding shutter to adjust feed rate; body material is fiberglass reinforced polyester resin, shutter material is laminate phenolic, and lid material is acrylonitrile-butadiene-styrene copolymer.

Bearing Life Analysis for Torque Converter Driven Power Trains, H. B. SCHEIFELE. Paper No. 227A. Simplified graphical bearing analysis for gear trains receiving their power from torque converters gives complete spread of bearing life values which is needed to select correct bearing; method simplifies work in obtaining graphical summary and is reduced to development of only one bearing life curve on log log-graph paper which can be used for every bearing in vehicle power train and in any speed ratio.

Chassis and Total Car Reliability, J. R. GRETZINGER. Paper No. S260. Definition of reliability, and reasons why organized effort for reliability is an increasing necessity; describes reliability program at Buick.

Initiating a Body Reliability Program, W. E. SEHN. Paper No. S261. Concept of reliability applied to automobile body. Responsibilities, organizational structure at Fisher Body.

Body Component Reliability, A. J. HOFWEBER. Paper No. S262. Application by Ternstedt Division, GM, of reliability function. Method of operation, new developments and their relation to reliability.

Pontiac Tempest, J. Z. DELOREAN. Paper No. S263. Development of Tempest. Design details of body, suspensions, drive line and torque tube, transaxle, and engine.

Scientific Highway Design for Safer Motoring, K. A. STONEX. Paper No. S264. Interstate highway system, proving ground road safety problems, guardrails, ditch section, roadside slope, 1960 design standard.

Engineering for Safety with Psychological Yardstick, G. J. HUEBNER, JR. Paper No. S265. Problems of getting customer reaction: limitations of "electronic brain" devices, such as radar brakes; application of techniques of experimental psychology to engineering problems.

Progress in Safe Vehicle Design, R. H. FREDERICKS. Paper No. S266. Accident reducing factors, principal causes of occupant injury, design features being developed that are proving highly effective in reducing injury in actual traffic accidents.

Corvair's Challenge to Body Builder, B. COTTER. Paper No. S267. Challenge of Corvair consisted of designing the parts, methods of assembly, and providing the facilities to build a satis-

Continued on page 94

Briefs of SAE PAPERS

Continued from page 93

factory frame-integral body for a car with aircooled rear engine.

Diesel Engine for Medium-Duty Trucks, W. E. PETERSEN. Paper No. S269. International Harvester D-301 engine of 112.5 hp at 3000 rpm is one of family of four diesels adapted from gasoline engines. Design changes required.

MATERIALS

Strength Prediction After Severe and Complex Thermal Histories, D. M. BADGER, C. D. BROWNFIELD. Paper No. 228C. To test structural materials used in vehicles in severe thermal environments, Northrop Corp. developed procedures which are based on use of rate-process theory in form of time-temperature parameter to overaging or annealing reaction; curves covering strength in tension, compression, bearing, and shear at several test temperatures after variety of exposure conditions were developed for Al alloy 7075-T6; application of same approaches to other alloys.

Inorganic Adhesive Bonding for Functional Temperatures Up to 5000 F, R. A. LONG. Paper No. 233A. Metallic, nonmetallic or ceramic adhesives; former covers soldering, brazing, and diffusion bonding; current art and refractory metals and alloys used; "in-situ" or diffusion bonding for applications ranging from 3000 to 6000 F; nonstructural ceramic cements and glassy bond adhesives and techniques; from 3000–5000 F, molten refractory carbides and borides, molten high melting point metals and metallic diffusion bonding processes seem applicable but require research and development. 21 refs.

Pressure Vessel Test Program for Evaluation of Rocket Motor Case Material, C. W. HAYNES, P. J. VALDEZ. Paper No. 233C. Study of materials for use in pressure vessels at Solar Aircraft Co. included series of 80 6-in. diam cylindrical test vessels and four subscale motor cases fabricated of H-11 type, 5% chromium alloy steel, which were burst tested; account of testing of these vessels and methods used to obtain information from tests.

NUCLEAR ENERGY

Experimental Boiling Sodium System, T. A. COULTAS, H. L. BURGE. Paper No. 234D. Alkali liquid metal boiling loop employing nozzle as thermodynamic load was constructed at Rocketdyne Div. to demonstrate feasibility of closed power loop; vapor temperatures of 1870 F were achieved for extended periods of time; approximate thermodynamic information obtained pertaining to pressure-temperature and dimerization relationships; instrumentation techniques for measuring pressure and boiler liquid level; in future work, turbine-generator unit will replace nozzle.

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How to Rate Filters By Effective Pore Size

Based on paper by

H. L. FORMAN and C. J. CASALEGGI

Purolator Products, Inc.

REINFORCED PAPER FILTER MEDIA can be satisfactorily and reproducibly rated according to pore size in microns, with the following test procedure:

1. A 3½-in. diameter sample of the filter paper is dried to constant weight at 150 C.
2. The weighed sample is mounted on a suction funnel setup (Fig. 1) and a dispersion of 0.12 g of glass beads with a known size distribution in one liter of benzene is filtered through the disc. Care is taken to keep the glass beads in suspension during the transfer and that all the glass beads are transferred to the test disc surface. Approximately 5 in. Hg vacuum is used as suction pressure.
3. The disc is then washed with normal pentane or petroleum ether to remove the last traces of the benzene.
4. The disc is dried to constant weight at 105 C.
5. The percentage of the beads retained by the test disc is then determined. The determination of the effective pore size of the filter medium is based on the assumption that the spherical particles larger than the average pore size of the filter medium are retained, while the smaller particles pass through. If glass beads with the distribution shown in Fig. 2 are used and it is assumed that 75% of the beads are retained, the filter medium would be rated as a 10-micron nominal

Continued on page 127

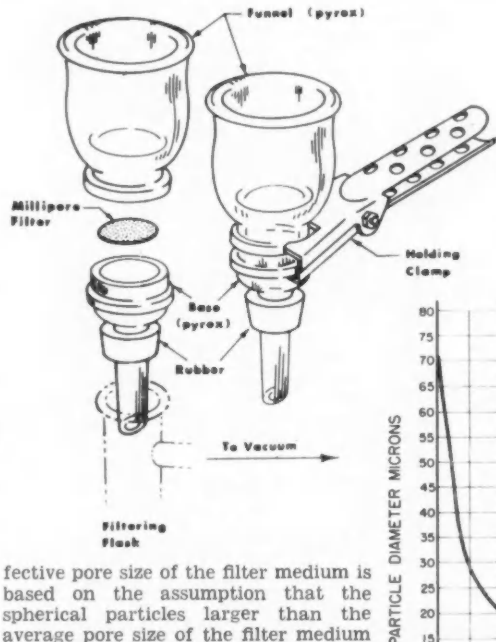


Fig. 1 — Diagram of effluent filtration setup for rating filters by pore size in microns.

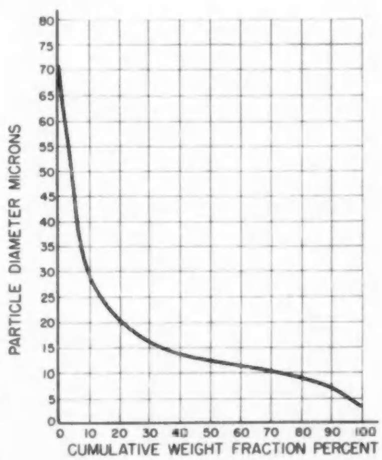


Fig. 2 — Particle size distribution curve — F-9 glass beads.

SAE NEWS

Dr. A. A. Kucher

1961 SAE President

Dr. A. A. Kucher, Ford Motor Company's vice president — engineering and research, is a man whose entire life has been characterized by great originality of thought and design. A man of broad interests, he has introduced fundamentally new principles in the main areas of his life's work: aviation, public transportation, refrigeration, air conditioning, and automotive engineering and research. In these fields, where Dr. Kucher holds patents on nearly 100 inventions and industrial processes, the technological advances that bear his name clearly show a perception for innovation.

Dr. Kucher was born March 20, 1898, in Jersey City, N. J. As a youth, his interest in science and engineering developed early. Coincidentally, Dickinson Industrial High School in Jersey City had just become the first public secondary school in the U. S. to offer a complete engineering course. Thus, the man and his times were well met. His subsequent years of independent research and his many contributions to the field of engineering culminated in his being awarded an honorary degree of Doctor of Engineering from the University of Michigan in 1954. Another honorary doctorate was awarded him in 1959 by Michigan College of Mining and Technology.

Starts in Aircraft

With a solid grounding in engineering fundamentals, Dr. Kucher went directly from school into the field of aviation where he experimented with new structural forms for aircraft. Immediately after World War I, while only 20 years old, he designed and built one of the first monocoque fuselage airplanes in the U. S. This was a new principle in aircraft design that used the covering of the fuselage for structural support. At a later time, he was associated with the College of the City of New York as an instructor in aerodynamic theory and practice.

When he was not yet 30 years old, he launched the Kucher Airplane Co., and again uniqueness characterized his work. In this venture, he conceived and patented a fundamental concept for aircraft design in which all surfaces of the wings and fuselage contribute to lift. This design increased the lift-to-drag ratio by 50% over aircraft designed by the standard practice of that time. His aviation interests continued through the mid-1940's as vice-president of research for Bendix Aviation Corp.

In quite a different field, Dr. Kucher recognized many years ago that the limiting factor for speed in ground transportation was the wheel. To overcome this limitation, he proposed a principle of "levitation" that permits vehicles to glide on a thin film of air at speeds in excess of 200 miles an hour. Now being developed under his direction at Ford Motor company, this vehicle — the Ford Levacar — is envisioned as a multi-passenger coach capable of providing swift public transportation, on rails, for medium-distance runs of from 100 to about 1000 miles.

Refrigeration Achievements

In the refrigeration field, Dr. Kucher's most important contribution was the development of hermetically sealed motor-compressor units, a principle universally accepted today. He first entered the refrigeration business with the Clothel Refrigerator Co. of Bayonne, N. J., in 1919, and throughout most of the 1920's was a consulting engineer for Westinghouse Electric and Mfg. Co. in Philadelphia. In the latter capacity he directed an extensive program of development in sealed-unit refrigeration. In 1931, he joined the Frigidaire Division of General Motors Corp. and became manager of research and air-conditioning, a post he held until 1942.

Dr. Kucher's novel approach to air conditioning resulted in his developing an efficient home air conditioner that operates with a continuous supply of fresh air. In contrast to the recirculating conditioner, which uses the same air over and over again, the non-recirculating, all-fresh-air device draws a constant change of air from the outside, conditions it and, under pressure, delivers it to the desired living areas.

Research Administrator

As an industrial research administrator, Dr. Kucher has been a strong advocate for long-range fundamental research. Because most manufactured products are derived from diverse technologies, he has long been concerned with adapting new scientific ideas and applying newly discovered scientific principles to product design and manufacturing processes.

Following his initial research direction at Westinghouse and Frigidaire, he became director of research at Bendix in 1942 and established the Bendix Central Research Laboratory. He reorganized and coordinated the complex research activities of that company and soon became vice president in charge of long-range research and development.

In 1951, Ford Motor Co. asked Dr. Kucher to form and direct what has become his greatest achievement — Ford's Scientific Laboratory. As a natural consequence of his earlier success in research administration, he was called upon to organize a laboratory for fundamental research in fields of science underlying the broad technological interests of the automotive industry.

Out of this laboratory have come fundamental findings in such fields as magnetism, free radical structure, crystal analysis, and polymer molecular arrangement — findings which relate to the structure of matter — as well as the development from basic research of such materials and devices as ultra-high-strength steels for a myriad of automotive applications, titanium-carbide cutting tools for low-cost precision parts fabrication, ductile iron-aluminum alloys for high-temperature engine components, and an automotive gas turbine that promises the fuel economy and operating performance of diesels weighing four times its weight.

In 1957, Dr. Kucher was named to the position of vice president-engineering and research for Ford Motor Co. In this capacity, he manages one of the most complex and complete industrial engineering and research centers in the world. Activities under his direction include fundamental inquiries in basic research and applied research on future vehicle developments. He also has functional supervision of engineering for all Ford Motor Company products.

Dr. Kucher was chairman of the SAE Technical Board in 1960, and, in 1960 also, had served one year of a two-year term as a member of the SAE Board of Directors.

Varied Activity

He is also a member of the Board of Trustees of the Rackham Engineering Foundation (Detroit), the Board of Directors of the development council of the University of Michigan and the Board of Trustees of Cranbrook Institute, Bloomfield Hills, Mich.

Innovation of a conceptual nature is the outstanding common denominator that characterizes Dr. Kucher's diversified career. His ability to develop new principles and techniqes and to apply new scientific information to engineering practice runs like a silken thread throughout his activities and constitutes his unique contribution to the advancement of engineering as a profession.

Kucher

Delaney

Allmendinger

Dunn

Dyment

Hibbard

Kelley

Norrie

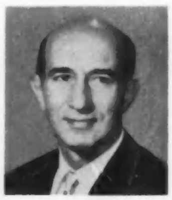
Swansen

Ford

Frey

Garwood

Kittler



Manganiello

McFarland

Robinson

Ackerman

Isbrandt

Klein

Liddell

Kibbee

MacGregor

Chesebrough

Raymond

SAE 1961 Board of Directors

A. A. Kucher .... President

G. A. Delaney .... Treasurer

Directors

Three-Year Term 1961, 1962, 1963

P. F. Allmendinger — H. L. Hibbard
J. H. Dunn — O. K. Kelley
J. T. Dyment — R. C. Norrie
T. L. Swansen

Two-Year Term 1961, 1962

W. F. Ford — M. J. Kittler
M. L. Frey — E. J. Manganiello
M. F. Garwood — F. R. McFarland
R. R. Robinson

One-Year Term 1961

P. C. Ackerman — A. L. Klein
R. H. Isbrandt — G. J. Liddell

Also serving on the 1961 Board of Directors will be:

Directors

L. C. Kibbee — J. R. MacGregor

* See note below

Past-Presidents

H. E. Chesebrough — Leonard Raymond

Joseph Gilbert .... Sec. and Gen. Mgr.

* The 1961 Board of Directors will elect a new Director to serve for 1961 to fill the unexpired term of A. A. Kucher, who had been elected to serve as a Director for 1960–1961.

For more information about the 1961 SAE BOARD of DIRECTORS . . . see the 1961 SAE Journal Roster issue, pages 4–9.

Selby Doubly Honored with Springer and Ford Awards

Theodore W. Selby (right) receives the Russell S. Springer and the Ford Memorial Awards from SAE Past-President James C. Zeder (left) while Max M. Roensch (center) Detroit Section chairman looks on.

THE RUSSELL S. SPRINGER and the HENRY FORD MEMORIAL AWARDS — both designed as annual honors for the young SAE member — were received by Theodore W. Selby in a double certificate-and-cash presentation at Detroit Section's November meeting.

The Springer Award went to Selby as youngest author whose paper appeared in 1960 Transactions . . . and the Henry Ford Memorial Award as author of the best paper by an SAE member under 33 years of age. The paper "Automatic Transmission Fluid Viscosity at Low Temperatures and Its Effect on Transmission Performance" appears on p. 457 1960 SAE Transactions.

Selby started with General Motors in 1953, and is now senior research chemist in the research laboratories. He received his B.S. in chemistry from University of Detroit in 1950; his M.S. in physical chemistry from Wayne University in 1960, where he is currently working toward a Ph.D. He was born in Nebraska City, Neb., on Oct. 19, 1928.

Students Hear Top Executives on Aerospace Careers

HOW BEST THE ENGINEER CAN PROFIT from a career in the aerospace industry was the topic which brought together top executives and students in a panel session on Oct. 12 at SAE's National Aeronautic Meeting in Los Angeles.

Students from 23 schools and colleges in the area made up a majority of the 230 audience which participated.

George F. Douglas, Northrop's vice-president of engineering, Norair Div., was panel chairman. Thomas V. Jones, Northrop's president, was keynote speaker. Charles Strang, Douglas' chief engineer for transport aircraft, E. R. Van Driest, North American's Aerospace Laboratories director, and A. C. Ingersoll, dean of University of Southern California's Engineering School, were the panel.

(Standing) George F. Douglas, Northrop's Norair Division vice-president of engineering, addresses the panel and a "full-house" audience at the SAE Special Student Session in Los Angeles. (Seated, left to right) Thomas V. Jones, Northrop's president and keynote speaker; Charles R. Strang, Douglas's chief engineer for transport aircraft; E. R. Van Driest, North American's director of Aerospace Laboratories; Alfred C. Ingersoll, dean of University of Southern California's School of Engineering.

Speaking on "The Economic Use of Resources," Jones stressed brainpower as the country's most valuable asset. The ideal solution to any problem, he said, is one that can be applied to a number of problems . . . and gave as example development of the boundary layer wing control, which permits of many applications for both military and commercial operations. Let's stop trying to build a better mouse trap, but rather, find a use for the mice, Jones said in closing his talk.

The transition from aeronautics to astronautics has brought about many job opportunities, Strang said, especially in the missile research field.

Van Driest told of the problems involved in establishment of a lunar base . . . and how all forms of engineering would be utilized in such a venture.

Ingersoll reviewed the role of the university in training personnel for these changing times . . . and related the difficulty being experienced in obtaining the necessary funds to permit of the quick transition. Right now, he said, the university is placing emphasis on the fundamentals of aerospace technology.

In discussion, the correctness of the term "aerospace" was questioned. Van Driest, it was noted, had said that space does not contain air as we know it. Strang vouched for the term's correctness, however, pointing out that the first and last stages of space flight are made through the earth's atmosphere.

Jandasek on Torque Converter as 7th Buckendale Lecturer

V. J. JANDASEK, 1960 L. Ray Buckendale Lecturer, chose "Design of the Single-Stage, Three-Element Torque Converter" as the subject of his lecture-presentation before SAE's ICEAE on Wednesday afternoon, Jan. 11, in Detroit's Cobo Hall. He is Ford's executive engineer in charge of Advanced Development and Experimental Operations in the Transmission and Chassis Division.

Jandasek's first experience with torque converters dates back to 1934, when he engaged in experimental fabrication and test of some of his father's early developments in this field. After receiving his B.S. in mechanical engineering from Illinois Institute, he worked for seven years on engine development principally with International Harvester Co. and McCulloch Motors Corp. At McCulloch, he was in charge of the engine test laboratories. For five years he was with Bendix Aviation and Borg-Warner, where he was concerned with direction of design and development of torque converters and automatic transmissions. He started at Ford in 1950 in the same capacity, and in 1957 became executive engineer-automatic transmission and axle, in the Transmission and Chassis Division. He was appointed to his present position in 1958.

Jandasek

The L. Ray Buckendale Lectures — sponsored by SAE in commemoration of its 1946 President — provide for a yearly cash award and certificate for a lecture and monograph by an authority in the technical areas of commercial or military on-or-off-the-road ground vehicles. The Lectures are directed toward filling the needs of young engineers and students for up-to-date practical knowledge.

P. H. Pretz chairmanned the L. Ray Buckendale Lecture Committee which chose Jandasek as 1960 lecturer. As committeemen there were H. O. Flynn, E. P. Lamb, R. C. Norrie, and E. F. Petsch.

AVAILABLE NOW—

Discussions of the following papers were not printed in the 1960 SAE Transactions:

- **"The Identification and Characterization of Rumble and Thud," by E. S. Starkman and W. E. Sytz.**
- **"Radioactive Cylinders — A Tool for Wear Research," by W. C. Arnold, V. T. Stonehocker, W. J. Braun, and D. N. Sunderman.**

Comments by Jerar Andon of General Motors Corp. and Milton D. Behrens of Texaco, Inc. of the Starkman paper; and by James J. Gumbleton of General Motors Corp. of the Arnold paper are now included in a booklet, along with rebuttals by the authors.

Copies of the booklet are available free from SAE Headquarters, 485 Lexington Avenue, New York 17, New York

SAE LETTERS FROM READERS

From:

Charles F. Sanderson (M'35)
Director
Sanderson Motor Co. Pty. Ltd.
Victoria, Australia

Dear Editor:

During the 25 years of my membership in SAE, I have always looked forward to the arrival of the Journal, which is of great help and keeps one abreast of developments in the automotive field.

That the Society has been the means of continued advancement in automotive engineering cannot be denied, and it is to be hoped that it will long continue its wonderful progress.

From:

V. L. Narayanan
Principal
Birla College of Engineering
Pilani (Rajasthan) India

Dear Editor:

We are interested in obtaining copies of the Transactions of the Society of Automotive Engineers from 1935 onwards.

It may be that some SAE members would like to dispose of their back numbers.

The volumes are required for our college library, and I shall be grateful for any help given.

From:

Murray Fahnestock (M'21)
524 So. Murtland Ave.
Pittsburgh 8, Pa.

Dear Editor:

In 1959, a plan for "completing the files" of SAE Journals and of SAE Transactions at the Carnegie Library (located midway between Carnegie Institute of Technology and the University of Pittsburgh) and also at the college libraries of Tech and Pitt, was approved by the Governing Board of SAE Pittsburgh Section.

We first wrote to the librarians and received "lists of missing copies." Now we are asking SAE members (who, through lack of space at office or home, have been told by their wives to "throw out those dusty magazines!") to contact our Archives department to find if these valuable magazines cannot be saved to complete library files for use of our student members at Tech and Pitt.

Any Section having a college or lilibrary in its vicinity might consider this, as few libraries have complete files. Older SAE members may move into smaller apartments or move away, and the older magazines should be saved now before it is forever too late.

Yoshiki Visits SAE Headquarters

THE GENERAL DIRECTOR OF THE SOCIETY OF AUTOMOTIVE ENGINEERS OF JAPAN, T. Yoshiki, visited SAE Headquarters late in October to talk with SAE officials about plans for the International Automotive Engineering Congress and Exposition. Mr. Yoshiki has just returned to the United States to attend the ICEAE.

His October visit was part of a world tour which took him to the European automobile shows as well as to Detroit and other United States areas.

At SAE headquarters, he talked with SAE Past-President Leonard Raymond (seated right); SAE Secretary and General Manager Joseph Gilbert (standing right); and SAE Advisory Consultant John A. C. Warner (standing left). Mr. Yoshiki is seated left.

PROF. ERWIN H. HAMILTON (right) reads the certificate of appreciation from SAE's Board of Directors, presented by SAE Director R. R. Higginbotham at Metropolitan Section's October meeting . . . where Hamilton, was greeted by his many friends as "SAE's Dean of Faculty Advisors."

For 31 years, Hamilton had been faculty advisor of SAE's Student Branch at New York University. He helped to organize the Branch in 1929, and had guided its activities until his retirement from the teaching profession in mid-1960. The certificate reads:

> "In recognition for his active part in organizing Student Branch of the Society of Automotive Engineers at New York University in 1929 . . . and his guiding service to the Student Branch as its Faculty Advisor since that date . . . the Board of Directors of the Society is pleased to recognize Professor Erwin H. Hamilton as a pioneer in SAE Student Activities upon his retirement from active teaching and from his post as Faculty Advisor to the Student Branch."

Regional Section Officers Convene in Cleveland and Tulsa

5TH AND 6TH in the series of Regional Section Officers Conferences were those held in Cleveland and Tulsa in November during SAE's National Powerplant, and Fuels and Lubricants Meetings.

Six Sections were represented at the Cleveland Conference, and five in Tulsa — with a combined attendance of 48.

Discussion at both sessions centered mostly around programming Section meetings and student activities.

On programming of Section meetings, such questions as:

- **What constitutes a good Section meeting . . . a small interested group, or a large, partially interested audience;**
- **Are "special" meetings better meetings:**
- **How best to get the boss out to the meeting . . .**

set the tenor for idea-exchange.

Resultant discussion brought out agreement that the varied technical interests of the Section's members must be an important consideration in planning meetings — and that no single meeting will satisfy all.

Three requisites to a good Section meeting were outlined as:

- A good speaker on a technical topic of interest to a significant segment of the membership.
- Attendance of top engineering executives in the area.
- A well-operated social period to provide opportunity for engineers and executives to meet in a social environment . . . a real fellowship hour.

As a meeting-attendance spur, one Section found that its custom of supplying plant representatives with presale dinner tickets did much to bring out engineers to the meeting . . . as well as to provide the plant representative with opportunity to talk with prospective members.

Student activities in the Section were discussed at length in both sessions. It was generally agreed that a faculty man who knows the Society and recognizes the built-in potentials of SAE Student Enrollment is the Section's

SAE NATIONAL MEETINGS

- JANUARY 9–13 1961 • COBO HALL • DETROIT

INTERNATIONAL S·A·E AUTOMOTIVE ENGINEERING CONGRESS · EXPOSITION

- March 13–17

National Automobile Week (National Automobile and Production Meetings), The Sheraton-Cadillac, Detroit, Michigan.

- April 4–7

National Aeronautic Meeting (including production forum and Engineering display), Hotel Commodore, New York, N. Y.

- June 4–9

Summer Meeting, Chase-Park Plaza, St. Louis, Mo.

- August 14–17

National West Coast Meeting, Sheraton Hotel, Portland, Ore.

- September 11–15

National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display)
National Transportation Meeting
National Powerplant Meeting
. . . Milwaukee Auditorium, Milwaukee, Wis.

- October 9–13

National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- November 9–10

National Fuels and Lubricants Meeting, Shamrock Hotel, Houston, Texas.

best contact in the schools. A good faculty advisor is quick to realize what SAE Student Enrollment offers the student in preparing him for his industry job after graduation.

The 5-min, 16 mm color film, narrated by Harry Chesebrough and Paul Ackerman, on SAE's International Congress and Exposition of Automotive Engineering was shown at both sessions and information on how to obtain it for Section-meeting-showing was given.

FACTS ...

... from SAE literature

(Except where a charge is specifically indicated, SAE Journal will be glad to supply on request one copy of any of the pieces of SAE literature described. Address "Literature," SAE Journal, 485 Lexington Ave., New York 17.)

"**SAE HANDBOOK** is used daily in more than 6000 automotive companies." A survey of its users shows:

7% use SAE Handbook daily
16% less than once monthly
18% 10–20 times a month
59% 1–10 times a month.

These are "facts" taken from a brochure "1962 SAE Handbook" prepared for use of prospective advertisers in the 1962 issue.

THE MAIN OBJECTIVE of SAE Sections and Groups is to generate activities which extend the Society's professional benefits to members in their local areas . . . according to the "General Information" chapter in SAE Section Procedure. This handbook has been designed for use of Section officers and committee chairmen.

YOU'LL ...

... be interested to know

IN IRON MOUNTAIN ATOMIC STORAGE vaults, SAE has sufficient information and operating data to insure continuance of service to its members after any possible emergency.

Included are up-to-date membership ledger cards on microfilm, copies of SAE Journal, Transactions, Handbook and other pertinent material that would permit immediate pick-up of operations.

A small group of members, dispersed throughout the country, has access to the vault.

Section Meetings

BALTIMORE

January 5 . . . R. H. Finefrock, field engineering department, Firestone Tire & Rubber Co. "Future Trends in Tires." Elks Club, 307 W. Fayette St. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Cocktails 6:30 p.m.

CENTRAL ILLINOIS

January 25 . . . C. F. Garney, chief engineer, Mobil Oil Co. "High Pressure Hydraulics." Pere Marquette Hotel, Peoria. Dinner 6:30 p.m. Meeting 7:45 p.m.

CHICAGO

January 23 . . . Kenneth A. Austin, chief, industrial & marine sales and Louis Votre, senior project engineer, Lycoming Div., AVCO Corp. "Turbine Driven Amphibians — The New Trend in Fast Assault Craft." La Salle Hotel, South Bend, Indiana. Dinner 6:45 p.m. Meeting 8:00 p.m.

MID-MICHIGAN

January 30 . . . Edward Kelley, general mfg. manager, Chevrolet Eng. Center and Bart Cotter, chief engineer, Fisher Body Division. "The Chevrolet Corvair — Designed to Build." Bavarian Inn, Frankenmuth. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Plant Tour.

TWIN CITY

January 11 . . . Daniel J. Marien, manager of Regional Office of Industrial Chemical Division, Archer-Daniels-Midland Co. "Sperm Whaling and Its Use as Lubricants." President Restaurant, 3021 Nicollet Ave. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: Movies of Galapagos Islands.

WILLIAMSPORT

January 1 . . . Tour of Manufacturing, Test and Engineering Facilities of Williamsport Plant, Lycoming Division, AVCO Mfg. Corp. Dinner 6:45 p.m. Tour 7:45 p.m.

METROPOLITAN

January 5 . . . Senator A. S. Monroney, "New Frontiers of the Air." Brass Rail Restaurant, Fifth Ave. near 43rd St. Cocktails 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.
January 19 . . . Thomas Risk, Ford Motor Co. "Central Hydraulic Fluid System." Roger Smith Hotel, Lexington Ave., and 47th St., Manhattan. Luncheon Meeting 12:00 Noon — $3.00 inc. tip.
February 2 . . . J. M. Stout, Ford Motor Co., Lincoln Continental Division. "The 1961 Lincoln Continental Engine — A New Concept of Powerplant Reliability." Brass Rail Restaurant, Fifth Ave. near 43rd St. Cocktails 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

SOUTHERN CALIFORNIA

January 30 . . . C. L. Bouchard, manager, turbo mach. department, Ford Motor Co. "Gas Turbines in Transportation." Rodger Young Auditorium, 936 W. Washington Blvd., Los Angeles. Dinner 6:00 p.m. Meeting 8:00 p.m.

SOUTH TEXAS

January 23 . . . Dr. H. N. Abramson, director, department of applied mechanics, Southwest Research Institute. "Hydrofoil Boats." Petroleum Center Club, Loop 13, San Antonio, Texas. Dinner 7:00 p.m. Meeting 8:00 p.m.

WICHITA

January 19 . . . Bill Geist, numerical controls engineer, Boeing Airplane Co. "Application of Numerical Control in Industrial Processes." Dinner 6:30 p.m. Meeting 8:00 p.m. Special Feature: Tour of Boeing Plant following dinner in the Boeing Cafeteria.

SAE's CEP News

COOPERATIVE ENGINEERING PROGRAM

Preview of SAE Fuel Filter Test Methods Set for International Congress

THIRTEEN engineers now engaged in developing SAE fuel filter test methods will familiarize audiences with the progress and pertinent background on efforts to establish a uniform evaluating method of key diesel fuel filter characteristics. This will occur at two sessions of the SAE International Congress in Detroit's Cobo Hall on January 12.

Methods under study will help pump and engine manufacturers supply original diesel fuel filters and prevent, to a greater degree, the use of unsatisfactory field replacements.

When work was started four years ago by the SAE Fuel Filter Test Method Subcommittee, a simplified performance specification was envisioned. For example, a number series such as 2-35-22 would mean a rating of 2 micron filtration, 35 gal per hr, and 22 units of sludge capacity. Using much of the engineering personnel that developed the SAE Oil Filter Performance Test, the Subcommittee subsequently developed four groups of filter ratings.

(1) A number representing the flowrate in gallons per hr under which with filter will be operating. This value will be furnished by the application designer, whereupon the filter manufacturer or testing laboratory can then establish the balance of the ratings for a series of filter sizes when employed at the operating flowrate condition.

(2) A number which measures the size of a particle (in one thousandths of an in.) which will effectively be stopped by a filter. Many particles smaller than this rating will be removed by the filter, and only in isolated cases will larger particles pass.

(3) A number presenting the grams of an SAE fuel filter contaminant which can be retained before a limiting pressure differential across the filter is reached when operating at the assigned flow ratings.

(4) A number representing the degree of fuel cleanliness that will be maintained on the downstream side of the fuel filter in operation with the SAE fuel filter contaminant and at the assigned fuel flow rating. This will be expressed in grams per liter of fuel.

Those attending the two sessions will hear about:

- Service considerations
- Laboratory test system
- Flow restriction test
- Contaminants — field and laboratory phases
- Filtering ability test
- Analysis techniques
- Filter pore size test method
- Particle (pore) rating (foam-allover and mean flow pore phases)
- Media migration phase.

R. J. Pocock, Subcommittee chairman since 1955, will act as session chairman.

The 13 papers scheduled for presentation are now available as Vol. 1 of the SAE Technical Progress Series — Fuel Filter Testing. (For price, see p. 6.)

Following final Automotive Council approval which is expected soon, the fuel filter test methods will be published as an SAE Recommended Practice.

Jessie Singer Completes 45 Years at SAE

JESSIE SINGER, who completed 45 years of technical committee secretarial work on November 11, 1960, began her career when Coker Clarkson, SAE's first general manager, and four women *were* the headquarters staff. At the time, SAE had 1,634 members. (Today there are over 24,000.)

She started to work on SAE standards a few short years after arrival at SAE. Then, for more than 30 years, she was R. S. Burnett's right hand in the SAE Standards Department . . . predecessor of the present Technical Committee Division. Throughout those years, she played an important part with Burnett in compiling and publishing the SAE Handbook.

Since Burnett's retirement eight years ago, she has "brought-up" three technical committee staff representatives: D. L. Staiger, now associate manager, Publication Division; W. I. Marble, now manager, Activity Committee Division; and John Roop, for whom she currently is executive secretary.

Staff associates took note of Miss Singer's 45 years with SAE by presenting her with a gold watch and by honoring her at a luncheon.

SPECIALIZED SUPPORT EQUIPMENT NEEDS LEAD TO CREATION OF FOUR GROUPS — Specialized activities of SAE Committee GSE-1, Military Support Equipment, will be handled by four new Subcommittees created during a 3-day October meeting at the North American Air Defense Command Base, Colorado Springs, Colo. In announcing the step, GSE-1 Chairman **R. A. Taylor** (at right) pointed out the need for cooperative engineering action in the ground support area. Chairman Taylor is shown with **Col. J. W. Koletty** (center) and GSE-1 Vice-Chairman **R. G. Lohmann.**

The new Subcommittees and their chairmen are:

GSE-1A, Electrical/Electronic Military Support Equipment — W. Kaufman

GSE-1B, Pneumatic/Hydraulic Military Support Equipment — A. B. Billet

GSE-1C, Handling/Utility Military Support Equipment — C. B. Rogers

GSE-1D, Fuel Servicing Military Support Equipment — M. A. Stephens

21 Specs Form Basis Of Latest AMS Issue

TWENTY-ONE documents comprise the latest group of Aeronautical Material Specifications to be issued by SAE. A complete set of the one new and 20 revised specifications shown below is available in loose-leaf form. Each set, plus an Index of some 959 AMS's may be obtained for $4.75.

AMS 2310 — Transverse Strength and Ductility Requirements for Steel, Tensile Strength 260,000 psi, min

AMS 2201E — Tolerances, Aluminum and Aluminum Alloy Bar, Rod, Wire, and Forging Stock, Rolled or Drawn

AMS 2202D — Tolerances, Aluminum and Magnesium Alloy Sheet and Plate

AMS 2204A — Tolerances, Aluminum Rolled or Extruded Standard Structural Shapes

AMS 3326A — Silicone Rubber, Fuel and Oil Resistant (50–65)

AMS 3357B — Silicone Rubber, Lubricating Oil and Compression Set Resistant (65–75)

AMS 4116A — Aluminum Alloy Bars, Rolled, 1Mg-0.6Si-0.3Cu-0.25Cr (6061-T4)

AMS 4119A — Aluminum Alloy Bars, Rolled, 4.5Cu-1.5Mg-0.6Mn (2024-T351), Stress-Relief Stretched

AMS 4123A — Aluminum Alloy Bars, Rolled, 5.6Zn-2.5Mg-1.6Cu-0.3Cr (7075-T651), Stress-Relief Stretched

AMS 4169A — Aluminum Alloy Extrusions, 5.6Zn-2.5Mg-1.6Cu-0.3Cr (7075-T6511), Stress-Relief Stretched and Straightened

AMS 5352A — Steel Castings, Investment, Corrosion Resistant, 17Cr-0.5Mo (0.95–1.2C)

AMS 5526C — Steel Sheet and Strip, Corrosion and Heat Resistant, 20Cr-9Ni-1.4Mo-1.4W-Cb-Ti

AMS 5665F — Alloy, Corrosion and Heat Resistant, Nickel Base, 15.5Cr-8Fe

AMS 5741B — Steel, Corrosion and Heat Resistant, 13.5Cr-26Ni-1.75Mo-3Ti, Consumable Electrode Vacuum Melted

AMS 5754C — Alloy, Corrosion and Heat Resistant, Nickel Base, 22Cr-1.5Co-9Mo-0.6W-18.5Fe

AMS 5768E — Alloy, Corrosion and Heat Resistant, Iron Base, 20Cr-20Ni-20Co-3Mo-2W-1(Cb + Ta), Solution and Precipitation Heat Treated

AMS 6458A — Steel, Wire, Welding, 1.25Cr-0.65Si-0.50Mo-0.30V (0.28–0.33C), Vacuum Melted

AMS 6462A — Steel Wire, Welding, 0.93Cr-0.2V (0.28–0.33C) SAE 6130

AMS 7454C — Bolts and Screws, Steel, Low Alloy Heat Resistant, Normalized and Tempered, Roll Threaded

AMS 7493D — Rings, Flash Welded, Non-Austenitic Corrosion Resistant Steels

AMS 7496C — Rings, Flash Welded, Carbon and Low Alloy Steels

User Problems Analyzed at

CHEERS FOR A HIGHLY INFORMATIVE and inspiring meeting go to F. W. Petring, chairman SAE Transportation & Maintenance Activity Committee, R. R. Noble, chairman, SAE Truck & Bus Activity Committee, and E. D. Sowers, general chairman for the meeting.

LUNCHEON SPEAKER Welby M. Frantz, president, American Trucking Associations (left) enjoys a good joke with (center) Toastmaster John E. Carroll, president, American Hoist & Derrick Co., and Robert A. Hill, chairman of the host section, SAE Twin City section, who gave a welcoming address.

A capacity audience heard Mr. Frantz "acknowledge . . . that the technology of the trucking industry has come mostly from the SAE . . . and to express the recognition and everlasting gratitude of the trucking industry for what you and your colleagues have done for us."

He pointed out that the trucking industry has no resources for performing the research and engineering necessary for the technical phases of its operations. "If it weren't for SAE," he continued, "we might well be back in the days when we had a local van with a 4-cyl engine stuck out in front instead of a horse.

"A truck operator cannot . . . afford experiments with untried equipment. Fortunately, the work of the SAE makes this unnecessary . . . as the operator can place full confidence in the standards and recommendations of your Society."

He then reviewed a few of the technical contributions that, in his opinion, have had a tremendous influence on the practical operations of the trucking industry. He mentioned the standard established for the kingpin used on the trailer fifth wheel, which, he said, is the key to the modern trucking industry . . . for it makes possible the interchange of trailers among truck lines for movement between any two points in the country. He also mentioned contributions of the SAE Lighting Committee, the SAE Brake Committee, and many others. He pointed out that the SAE Handbook is the "bible" of the well-operated truck line.

National Transportation Meeting

THERE was plenty of evidence at the SAE National Transportation Meeting, held on October 25–27 in Minneapolis, to support the contention of Luncheon Speaker Welby M. Frantz, president of American Trucking Associations, Inc., that the SAE doesn't work in an ivory tower. In a meeting especially tailored to help solve the practical problems of the user, the technical sessions covered such down-to-earth operators' problems as corrosion, valve failure, selection of the right vehicle, effect of driver technique on vehicle dependability, problems of truck refrigeration, and suggestions for winterizing commercial vehicles.

To round out the technical dish, there were also:

- Two tours of local manufacturing plants — D. W. Onan & Sons, Inc., and Thermo King Corp. — where those who attended the tours could view the latest in truck refrigeration equipment.
- The luncheon at which Mr. Frantz spoke on, "Technology and the Trucking Industry"; and a buffet supper.

Here's a roundup of some of the material given at the technical sessions.

Reasons for Valve Failures

A systematic plan — including a detailed chart — for analyzing engine valve failures was outlined at the meeting. Valve failures were divided into two kinds: burning and breaking — and they are the result of both mechanical and thermal causes that are either "designed in," "built in," or "driven in" the engine. The author claimed that, despite the almost infinite number of variables that can combine to cause failure, if a mechanic follows the chart, step by step, he should have little difficulty in finding out why a particular valve failed.

Another author described how the physical design or shape of a valve and the materials of which it is made are of extreme importance in obtaining long valve life. It appears that, as engines impose more and more severe operating conditions, new designs, and materials for valves must be sought. Experimental alloys have been examined that are just as hard at 1400 F as they are at room temperature. It was also reported that certain ceramic coatings have been sucessful in reducing wear on heavy-duty valve stems.

Valve stems require lubrication to prevent wear; however, sometimes the oil will leak past the stem into the combustion chamber, where it is then burned out with the exhaust. A type of valve seal was described that wipes off excessive oil from the valve stem before it can seep into the combustion chamber. It has three parts: a Teflon sealing ring, a synthetic rubber jacket, and a steel retainer ring, which are united to from a single-piece ring.

Military Vehicles at – 65 F

Army Ordnance can successfully start and operate both spark- and compression-ignition engines at outdoor temperatures as low as – 65 F. To do this, it was reported, Ordnance uses two techniques to heat engines and related parts until they are warm enough for starting in extremely cold weather.

In the first, called "standby heat," a heater is continuously operated when the vehicle is not in use to maintain engine and battery at a high enough temperature to enable the engine to be started immediately when desired. A fuel-fired coolant-type heater is used to transfer heat directly to the engine coolant, which is circulated through the engine and battery heat exchanger.

With the other technique, called "quick-heat," the vehicle is allowed to drop to ambient. Before attempting to operate the vehicle, one uses a fuel-fired fresh-air heater to send hot air to the engine and batteries. Sometimes, a supplementary electric heater is also used.

In either technique, it was pointed out, it takes more than a heating system to start an engine successfully at low temperatures. The engine, battery, fuel system, and other parts must be in good condition and provided with the proper low-temperature fuels, lubricants, and antifreeze. Also, operators must follow recommended starting procedures.

Making Vehicles Better

Specific suggestions for improving the design of long-haul trucks, delivering trucks, public utility vehicles, and passenger cars for company fleets were given at the meeting by the users. Representatives of manufacturers listened to a range of complaints from petty gripes about windshield wipers that scratch to requests for major redesign of utility vehicles.

An engineer from TVA said that vehicles of public utility companies should be considered work machines, not moving billboards or payload carriers. He claimed that trucks in the 20,000–60,000 gvw range have been designed as if they never would have to cross country or do work on rough, unpaved roads. He called for some way of protecting the equipment on the underside of these vehicles.

He also said that engines and cooling

JUST A FEW of the members of the local committee who helped to organize and run the meeting are shown here. They are (left to right): W. E. Swenson, and T. E. Murphy, cochairmen, luncheon; J. J. Hite, treasurer, Twin City Section; and C. B. Palin, chairman, attendance promotion.

systems should be designed for nearly continuous stationary operation and called for engines of higher horsepower. Wider tires are needed, and torque-bias and locking differentials are a must for public utility trucks.

Rust or corrosion of the sheet steel in truck bodies, it was reported, is a major problem to be solved.

Another user said that door-to-door delivery vehicles must be short, low, compact, rugged, and have good maneuverability. They must also be easy to service, provide good driver visibility, and be designed so that the driver can have easy access and comfort.

There was also a call for lower first costs for long-haul trucks, lower operating costs, better salvage or resale value, and trucks that are easier and safer to drive. A user also asked manufacturers to select accessories with more care so that operators would have less trouble with parts, such as quick coupler on wiring harness, fuse holders, thermostats, meters, and seat adjustment mechanisms.

Papers . . .

at Transportation Meeting

Minimizing Corrosion on Trucks Thru Proper Design, **C. O. Durbin,** Chrysler Corp. (**248A**)

Why Valves Fail, **A. K. Hannum,** Thompson-Ramo-Wooldridge, Inc. (**249A**)

Why Valves Succeed, **L. F. Jenkins** and **T. N. Tunnecliffe,** Eaton Mfg. Co. (**249B**)

Controlling Valve Oil Consumption, **R. W. Heid, Jr.,** Perfect Circle Corp. (**249C**)

Two-Speed Tandem Drive Axles, **R. K. Nelson** and **L. J. Valentine,** Eaton Mfg. Co. (**250A**)

Winter Operation of Truck and Tractor Equipment in Iron Mining, **K. L. Prothero** and **John Meittunen,** United States Steel Corp. (**251A**)

Winterization of Military Vehicles, **Robert Shaw,** U. S. Army Tank Automotive Command (**251B**)

Winterization, **Lyle Harbeck,** Allen Industrial Products, Inc. (**251C**)

The Effects of Driver Technique on Vehicle Design, **C. A. Carlson,** International Harvester Co. (**253A**)

The Modern Commercial Vehicle and Its Complexities, **W. F. Eaton,** The Mason and Dixon Lines, Inc. (**253B**)

Problems with the Commercial Vehicle in the Utility Field, **W. A. Rigg** and **R. F. Jeide,** Northern States Power Co. (**253C**)

Papers are available through SAE General Publication Department. Prices: 50¢ a copy to members; 75¢ a copy to nonmembers.

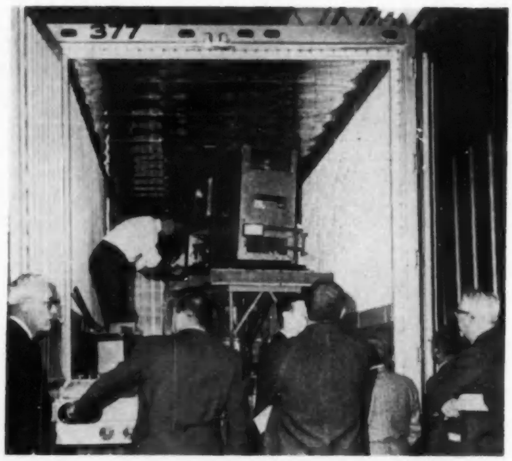
Technical Progress Series Vol. 2 — Selecting the Vehicle for the Job. Price: $2.00 to members; $4.00 to nonmembers.
Door-to-Door Delivery Vehicles, **H. G. Steigerwalt,** National Dairy Products Corp.

Over-the-Road Vehicles, **J. B. Boynton,** F. J. Egner & Son, Inc.

Vehicles for the Passenger Car Fleet, **H. O. Mathews,** Armour and Co.

Vehicles for Public Utility Service, **C. C. Hudson,** Tennessee Valley Authority.

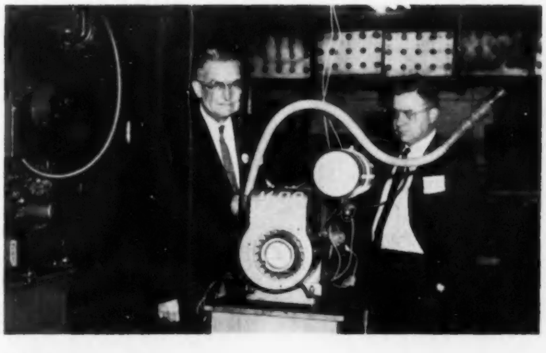
THERMO KING TOUR



THE LATEST IN TRUCK REFRIGERATION EQUIPMENT

was inspected by the groups that went on the plant tours to D. W. Owan & Sons, Division of Studebaker-Packard Corp., and Thermo King Corp.

ONAN TOUR



First SAE National Powerplant Meeting Held in Cleveland

The newly formed SAE Powerplant Activity (an expansion of SAE's former Diesel Engine Activity) held its first National Meeting in Cleveland.

Successfully "kicking-off" the SAE National Powerplant Meeting were technical papers on new small diesels, stress analysis, aluminum racing-car engines, design and development of small turbochargers, and many others.

As part of the Meeting, SAE'rs also had an opportunity to visit Alcoa's Cleveland Plant and to attend a dinner featuring W. H. Upson, famous humorist, as guest speaker.

New Compact Diesels

Caterpillar Tractor has developed a family of diesel engines which are smaller, lighter, and more powerful than previous models.

The new compact diesels depart from previous Caterpillar designs in that they have "cast-in" oil manifolds. Many other engine components have been redesigned to provide reductions in size, weight, and cost.

Intensive development work lies behind the ability of the new, smaller models to produce greater horsepower without sacrifice of quality or engine life. The 4-cyl D320 is approximately 18 in. shorter than its predecessor in both height and length and it weighs 500 lb less. The 4-cyl D330 shows a 6.4 in. reduction in length, a 6.1 in. decrease in height, and it weighs 385 lb less. The 6-cyl D333 is 4.7 in. less in width, 7.1 in. less in length, 3.0 in. less height, and is 350 lb lighter.

New Stress Analysis Technique

A new technique of experimental stress analysis called Photostress involves coating the part to be stress analyzed with a special transparent plastic. When a load is applied to the part, strain in the part is transmitted to the plastic coating, which becomes bi-refringent. By utilizing a white polarized light or room lighting, a complete color picture of the strain distribution over the entire surface is obtained with highlights on the areas of stress concentration. Since the change in color is directly proportional to the intensity of the strain, the location, sign, and magnitude of each strain can be determined instantaneously and with great accuracy. Stresses are calculated from the strain values.

The Photostress technique enables strain to be measured in static or dynamic conditions. The dynamic conditions are only limited by the speed of the recording device, either high-speed movies or photoelectric instruments. The new technique can be applied to such materials as cast iron, sheet metal, glass, wood, and even rubber.

Fire Pump Engine Leads to Racing Wins

A British aluminum fire-pump engine is the predecessor of a family of engines that have been winning world championship motor car races.

Fire-pump engine requirements are similar to those of racing-car engines: they must be light, compact, and reliable. So, soon after Coventry Climax Engines, Ltd. had developed a new 4-cyl aluminum fire-pump engine, racing car builders inquired about the possibility of producing full racing versions of this engine.

Coventry modified design to get higher engine speeds and racing engine performance. In 1954, modified versions of the engine were fitted to Kieft, Cooper, and Lotus racing cars, which performed well in LeMans and other races.

During the next five years several 4-cyl racing engines were designed featuring greater capacity and performance. An 8-cyl engine with 2½ liter capacity was developed to meet Grand Prix requirements.

In 1958, 4-cyl engines fitted to Cooper-Climax cars finished second and third in the German Grand Prix at Nurburgring. Later that year the Monaco Grand Prix was won.

In 1959, five out of the series of

Papers . . .

Presented at Powerplant Meeting

Compact New Caterpillar Diesels, **D. W. Knopf, M. B. Morgan** and **F. P. Buttke,** Caterpillar Tractor Co. **(254A)**

Stress Analysis of Aluminum V-8 Diesel Cylinder Block, **H. W. Van Camp,** Alcoa **(255A)**

New Techniques in Stress Analysis, **R. M. Law,** General Motors Corp. **(255B)**

Some Notes on the Coventry Climax Aluminum Engines, **W. T. F. Hassan,** Coventry Climax Engines, Ltd. **(256A)**

Design and Development of the Thompson Model 400 Turbocharger, **Hugh MacInnes,** Thompson-Ramo-Wooldridge, Inc. **(257A)**

Developing the Turbocharger for its Application, **J. M. Cazier** and **W. S. Lang,** Garrett Corp. **(257B)**

Evaluating Performance and Heat Rejection of Turbocharged Engines, **Robert Cramer, Jr.,** Murphy Diesel Co. **(258A)**

Cummins New PT Fuel Pump, **N. M. Reiners, R. C. Schmidt** and **Julius Perr,** Cummins Engine Co., Inc. **(258B)**

Piston Rings for Transportation Diesels, **C. F. Hyde, F. A. Robbins** and **P. R. Shepler,** Koppers Co. **(259A)**

The Development of American Marc Opposed-Piston Two-Cycle Diesel Engines, **Adolf Luerken** and **Cris Somhegyi,** American Marc, Inc. **(259B)**

Papers are available through SAE General Publication Department. Prices: 50¢ a copy to members; 75¢ a copy to nonmembers.

SAE POWERPLANT ACTIVITY COMMITTEE OFFICERS (left to right) K. Habermann, vice-chairman; G. Flynn, chairman; and F. A. Robbins, sponsor.

ENGLISH ENGINEER W. T. F. Hassan presented paper on Coventry Climax aluminum engines used in racing cars.

GATHERING FOR DINNER (left to right) T. R. Thoren, general chairman of meeting; A. T. Colwell, toastmaster; W. H. Upson, guest speaker; and L. L. Young, chairman, SAE Cleveland Section.

NEW, COMPACT TURBOCHARGED DIESEL aroused interest of members attending meeting. Caterpillar D330 engine produces up to 135 hp.

SAE PRESIDENT Harry E. Chesebrough (second from left) meets with SAE past presidents A. T. Colwell, R. R. Teetor, and G. A. Delaney (left to right).

eight World Championship Grand Prix races were won by Cooper-Climax cars fitted with $2\frac{1}{2}$ liter engines.

During 1960, Cooper-Climax and Lotus-Climax cars won all six world championships run through August.

Rating Turbocharged Engines

A method of rating turbocharged engines, based on a direct relationship between energy supplied in the fuel and the output measured at the crankshaft, gives revealing characteristic plots free from outside influences which normally mask the performance of an engine.

By breaking down the input energy into four principal heat flows, additional insight is gained into the factors which determine the acceptable rating of an internal combustion engine.

This technique can also be used to evaluate combustion chamber shape, compression ratios, turbocharger pressure ratios, and injector cam profiles. However, when the air trapped by the combustion chamber is adequate — the most important single factor in engine performance — such items as combustion chamber shape, injector design, and compression ratio become relatively less critical.

Alcoa Plant Visit

More than 200 SAE'rs toured the Alcoa plant and development laboratory in Cleveland. The plant visit was held in conjunction with the SAE National Powerplant Meeting.

Those attending the tour learned much about aluminum fabrication as they passed through the forging, sand casting, permanent mold casting, and plaster casting shops. A trek through the metallurgy labs was the highlight of the trip for many.

In addition to the tour, a panel discussion on Aluminum Fabrication, a dinner, and a technical session on Stress Analysis were held as parts of the day-at-Alcoa program.

Dinner Held at Museum

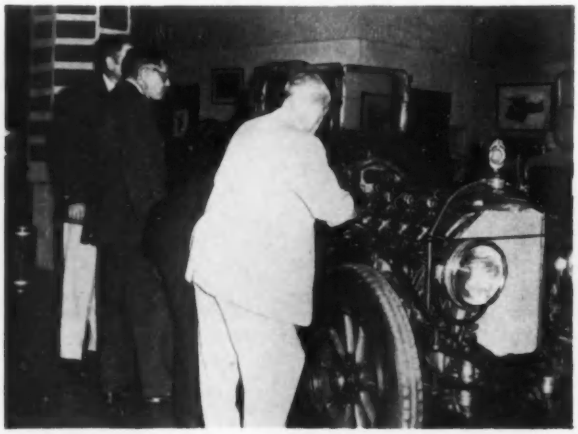
A social hour and dinner were held at the Thompson Auto Album and Aviation Museum. SAE's Cleveland Section was host for the dinner. Guest speaker at the dinner was W. H. Upson, the famous humorist and author of Saturday Evening Post "Earthworm Tractor," stories. Upson spoke on "Ergophobia." Acting as toastmaster at the dinner was A. T. Colwell, Vice President, Thompson Ramo Wooldridge, Inc.

The general chairman of the meeting was T. R. Thoren. Helping Thoren on the general committee were: J. R. Doyle, Gregory Flynn, Jr., H. F. Hostetler, T. C. Noon, R. A. Pejeau, R. R. Robinson, R. F. Schaefer, E. H. Scott, W. Weinkomer, and L. L. Young.

Officers of the Powerplant Activity are Gregory Flynn, Jr., chairman, and C. E. Habermann, vice chairman. F. A. Robbins was sponsor of the Meeting.

Chairman of SAE Cleveland Section is L. L. Young.

Glimpses from Thompson Auto Album and Aviation Museum



Field Trip to Alcoa Plant

STRESS ANALYSIS of an experimental tank road wheel mounted on a hydraulic press was discussed by Don Kent, Alcoa development engineer. Direction of stress patterns on the part were highlighted for easy observation by the SAE visitors.

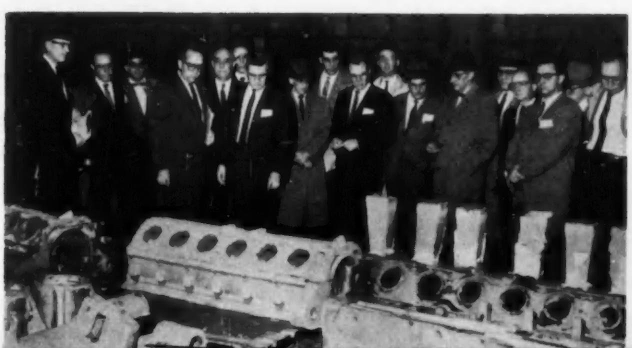
HOW ALCOA MAKES AND USES SHELL DRY SAND and sodium silicate — varbon dioxide bonded cores in its foundry operations was explained to SAE visitors by Don Lippenberger, chief metallurgist for Alcoa's Cleveland sand foundry.

JOINING METHODS developed by Alcoa were shown to SAE visitors by Frank Spexarth, engineer in the joining section at Alcoa's Cleveland sales development division. Included were aluminum cylinder heads and electric skillets, whose components were joined by brazing, pressure bonding, or adhesive bonding

IN THE PLASTER DEPARTMENT of Alcoa's Cleveland sand foundry, Foundry Superintendent William Hoppman showed various intricate, high-strength aluminum castings made by the plaster process, including impellers and a diesel engine fan shown in this picture.

CORE ASSEMBLY for the V-12 aluminum diesel crankcase is discussed by John Wallis, assistant superintendent of Alcoa's Cleveland sand foundry, with some of the 280 SAE representatives who toured Alcoa

AT ALCOA'S SAND FOUNDRY, SAE'rs saw a V-12 cast aluminum diesel engine crankcase in three stages of fabrication: (right to left) Rough casting before removal and trimming operations, rough casting after sand blasting, rough casting after trimming. In the foreground are other aluminum castings including lamp post bases and Navy hydraulic pump bases.



Fuel-Engine Studies

SAE National F & L

The problems of matching fuels and lubricants to automotive engines were brought to light at the 1960 edition of SAE's National Fuels and Lubricants Meeting held in Tulsa.

Well attended were technical sessions on fuels and engines, engine operating sequences for service MS, diesel fuels and lubricants, and gasoline volatility. Other popular events held as part of the Meeting were a buffet luncheon, fellowship hour and dinner, and field trip to American Airlines Maintenance and Engineering Center.

High Compression Ratio Test Engine

A new fuel test engine has been developed to replace older test engines that have obsolete low compression ratios. The new 371 cu in. V-8 test engine will be used to test the compatibility of fuels and lubricants for high compression ratios. It will operate at compression ratios of 10/1, 12/1, and 15/1. The engine, developed by General Motors, was called "a contribution by the automotive industry to an overall cooperative program for the study of engine-fuel relationships."

High Compression Ratio Fuel Tests

A series of fuel tests have been made using two experimental 1956 engines with compression ratios of 12/1 and one 1959 engine with a compression ratio of 15/1. Major findings of this research on fuels for high compression engines in normal road usage are:

1. Full- and part-throttle knock, deposit ignition, and spark-plug life are important in determining fuel composition requirements for high-compression cars. With present knowledge these requirements may be met for the 12/1 compression ratio, but not the 15/1.
2. At 12/1 compression ratio, typical leaded commercial fuels of 102 Research and 95 Motor O.N. with 0.5–0.8 theories of phosphorus should be satisfactory. Metal-free fuels of similar octane quality would also be satisfactory. Oil metals are not a factor in deposit ignition at this compression ratio. A volatile paraffinic fuel with lead and no phosphorus at similar octane levels would be another possibility.
3. Research and Motor octane ratings and deposit-forming characteristics of fuel components and not "surface ignition resistance" are important qualities in compounding fuels for high-compression engines.
4. Part-throttle knock and high compression ratios are partners.
5. As compression ratios go up, spark-plug life, even with phosphorus fuels, may lessen.

Engine Operation Sequences for Service MS

The selection of the proper lubricant for automotive engines is a complicated one and has, in years past, been based

PETROLEUM'S FUTURE is discussed by (left to right) W. J. Ewbank, Brig.-Gen. C. W. Clark, and T. W. Legatski. Ewbank is chairman of SAE MID-Continent Section. Gen. Clark was guest speaker at the dinner and spoke on "The Influence of Petroleum on the Future Army." Legatski was toastmaster at the dinner.

Highlight Meeting

DISCUSSING MEETING PROGRAM are Gil Way (left) and F. E. De Vore. Way is chairman of the SAE Fuels and Lubricants Activity Committee. De Vore was general chairman of the Meeting.

on a number of engine test sequences. As an oil passes these engine tests it is then given a MS (most severe) rating and is qualified for use by the public.

Typical of these tests is one which will measure cam and tappet scuffing in "most severe" engine service in relative short time. The test, called Test Sequence IV, is specifically designed to determine the adequacy of engine lubricant antiscuff properties. The test used a DeSoto V-8, 361 cu in. engine with a 136% valve spring load. Engine speed was 3600 rpm, no-load. Water temperature was 180 F when running and from 35 to 70 F during shutdown. The engine was run for two hours and shutdown for two hours until 12 hr of running time had been accumulated. The results obtained are said to correlate well with field experience.

Survey Traces Cold Weather Engine Problems

Difficult starting in cold weather, sluggish operation during warmup, and stalling were the major complaints of 1283 car drivers in a survey of motorists in Syracuse, New York, and Philadelphia.

A questionnaire asked which winter performance problems were most prevalent, which brands and grades of gasoline gave the best performance, and which makes of cars were involved.

Thirty-eight per cent of the motorists reported sluggish operation during the engine warmup period; 24% mentioned stalling as a problem; 18% reported starting difficulties.

Thirty-eight per cent of those answering the questionnaire were of the opinion that winter performance varies with changes in gasoline brand.

Variations in the degree of problem incidence with car manufacturer indicates that engine design is a significant factor affecting winter performance. Also, because of the carburetor-icing problem and geographic differences in driving habits, winter-performance problems aren't limited to the colder climates.

Test Rates Throttle Icing

A test method has been developed for rating the throttle icing tendencies of gasolines. The test continuously meters test or reference samples of fuel upstream from the throttle plate. Through interpretation of time-rate-of-rise of induction vacuum, conclusions can be drawn regarding the resistance of fuel compositions and gasoline additives to carburetor icing.

Surveys shows a wide variation in the carburetor icing tendencies of gasolines now on the market. Partly, this variation results from rather wide differences in volatility. Thus, it is likely that changing fuel volatility is a more effective way of combating icing than adding alcohol to the fuel. However, the gasoline must retain sufficient volatility to ensure good cold-engine acceleration performance.

Buffet Luncheon

A buffet luncheon was held as part of the SAE National Fuels and Lubri-

Papers . . .

Presented at Fuels and Lubes Meeting

Design of a High Compression Ratio Test Engine for the Petroleum Industry, **B. J. Mitchell, G. P. Ransom** and **H. E. Reed,** General Motors Corp. **(260A)**

Fuels for High Compression Engines, **B. L. Hurd,** Atlantic Refining Co. **(260B)**

Surface Ignition Survey of New Passenger Cars, **E. F. Koenig, J. R. McLean** and **E. J. Buchanan,** Texaco Research Center **(260C)**

An Engine Test for Predicting the Performance of Engine Lubricants in 'Most Severe" Passenger Car Service, **P. A. Bennet, C. K. Malone** and **C. K. Murphy,** General Motors Research Labs. **(261A)**

Test Sequence IV — Measuring Cam and Tappet Scuffing in "Most Severe" Engine Service, **E. W. Beckman** and **W. K. Fales,** Chrysler Corp. **(261B)**

Engine Tests for Evaluating Crankcase Oils in Stop and Go MS Service, **J. C. Gagliardi, F. E. Ghannam, R. F. Gasvoda** and **R. I. Potter,** Ford Motor Co. **(261C)**

Does the MS Test Predict Field Performance?, **C. C. Colyer** and **T. B. Tom,** Standard Oil Co. **(262A)**

Motor Oil Evaluation — Laboratory Engine Tests for MS Service and Field Performance, **A. E. Brenneman, D. R. Harsell, N. R. Roux** and **G. K. Vick,** Enjay Labs. and Research Affiliates **(262B)**

Some Problems with Determination of Used Oil Insolubles and Their Relation to Engine Cleanliness, **P. A. Asseff** and **R. K. William,** The Lubrizol Corp. **(262C)**

Combustion Characteristics of Compression-Ignition Engine Fuel Components, **D. R. Olson, R. D. Quillian** and **N. T. Meckel,** Southwest Research Institute **(263A)**

The Effect of Variables on the Caterpillar L-1 Test, **J. J. Orzing, Jr.** and **H. B. Anderson,** Texaco Research Center **(263B)**

Save Time in Formulating Diesel Lubricants, **A. A. Schetelich** and **H. E. Deen,** Enjay Labs. **(263C)**

The Motorist Looks at Winter Performance, **C. S. Gilbert, Jr.** and **E. F. Marshall,** Sun Oil Co. **(264A)**

A Test Method for Rating the Throttle Icing Tendencies of Gasolines, **J. H. Freeman, Jr.,** Pure Oil Co. **(264B)**

Volatile Fuel, Road Effects, and Film Studics, **W. A. Gartland,** Ford Motor Co. **(264C)**

Papers are available through SAE Special Publications Department. Prices: 50¢ a copy to members; 75¢ a copy to nonmembers.

cants Meeting. The "Gay Notes," Tulsa's outstanding barbershop quartet, were on hand to entertain members and guests.

General Clark Cites Petroleum's Future

The military's use of fuel will continue to rise for some time to come and the Army will continue to be petroleum orientated. That's what guest speaker Brig. Gen. C. W. Clark, chief of the research and development division, Office of Chief of Ordnance, told SAE'rs attending a dinner held as part of the Meeting.

Since more mobility is needed by the military in atomic war, both size and number of military vehicles will increase, Clark predicted. In fact, under a combat team organization now being considered, a rifle company will have 37 vehicles ranging from jeeps to tanks.

Despite the research being done on exotic fuels, Clark forecast that petroleum products will continue to power most military vehicles for at least another 10 years. Considerations such as capital investment, required lead time, and training requirements preclude switching to another power source even if available, he said.

At present, the Army is trying to reduce fuel consumption through increased vehicle efficiency. This will ease logistics problems and extend vehicle range, Clark said.

Army policy, Clark revealed, calls for the design of vehicles to operate primarily on combat gasoline or diesel fuel. The increasing use of diesels has presented problems of limited speed range, flexible operation over a wide range of temperatures and loads, as well as fuel design problems. These problems must be overcome in adapting diesels to military ground vehicles, Clark said.

The Army is working on multifuel engine and turbine designs, Clark reported in his speech, "Influence of Petroleum on the Future Army."

The Mid-Continent Section of SAE hosted a Fellowship Hour before the dinner. W. J. Ewbank is chairman of Mid Continent Section. The general chairman of the Meeting, F. E. DeVore, introduced guests at the dinner table and T. W. Legatski, toastmaster, introduced Gen. Clark.

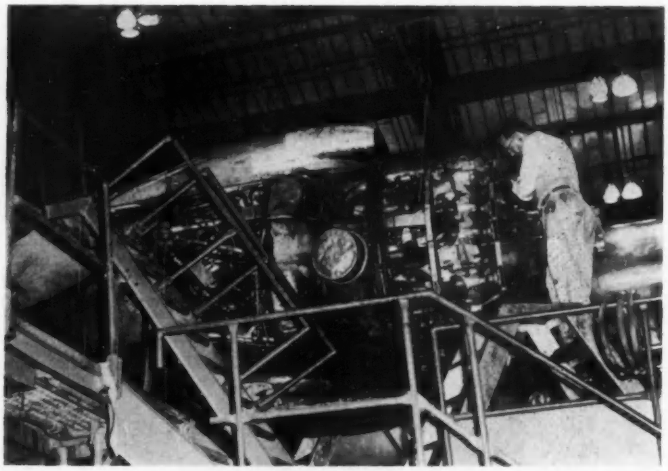
Field Trip to American Airlines

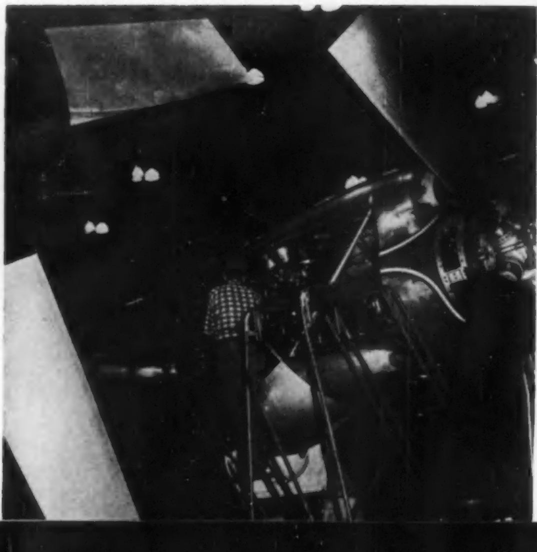
SAE members were guests of American Airlines on a tour of their Tulsa Maintenance and Engineering Center. American's Maintenance and Engineering Center is one of the largest and most modern in America today. Recent installation of jet maintenance facilities made this tour of particular interest. Members and guests visited the turbine and piston powerplant overhaul department, the engine testing cells, the instrument shop, paint shop, and the accessory overhaul and airplane overhaul departments.

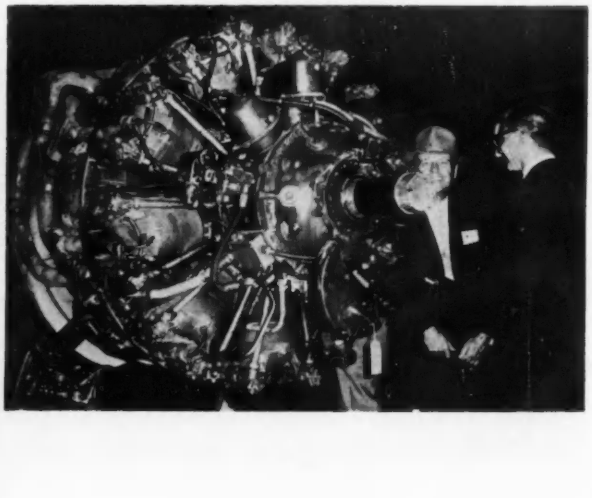
Members of the General Committee who were instrumental in the success of the Meeting are: W. L. Banks, H. M. Carey, J. L. Carson, J. S. Crawford, I. E. Flaa, R. E. Linnard, W. W. Schafer, and W. L. Thompson.

Representing the SAE Fuels and Lubricants Activity were Gilbert Way, chairman; E. H. Scott, vice chairman; J. E. Taylor, sponsor.

Field Trip to American Airlines Maintenance and Engineering Center





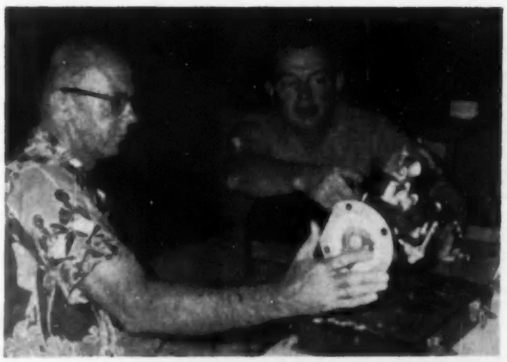


Rambling . . .

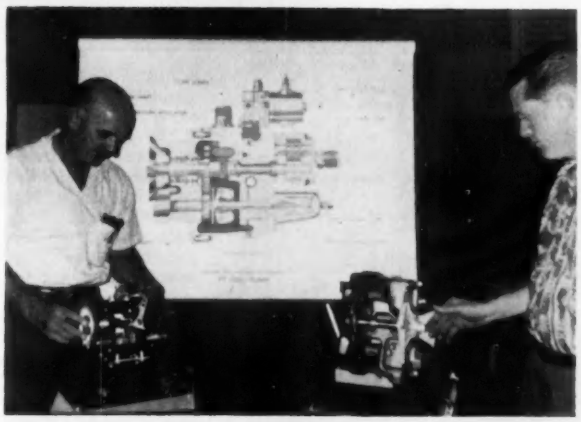
Through the Sections

CUTAWAY SECTIONS of three stages of Injection pumps were displayed at **HAWAII SECTION**, October 18 to illustrate the results of research at Cummins Engine Co.

Walter Featherstone, Training instructor for Cummins stated that the first stage reduced the pump to about half the size of the original pump and reduced the number of parts as well. The second stage of development repeated the operation and had similar results.



Walter Featherstone, (right) speaker at the Hawaii Section, explains cutaway model to Warren Flagg, (left) manager, Truck & Equipment Division, Schuman Carriage Co., Ltd.



Leonard O. Lister, (left) master mechanic, Waialna Sugar Co. and David L. Sherpherd, (right) field service instructor, Cummins Engine Co. observed models of the injection fuel pumps at Hawaii Section.

WOLF WAGONS are being used by private fleet owners as a means of reducing labor costs. These vehicles are like highway size cargo boxes with no cab protruding from the body, but with a driver sitting in the front left hand corner. Each has its own power and steering capacity, and is on its own, a complete truck. Several of these units can be coupled together with a driver in the lead vehicle only. With this system, one driver can deliver two or three of the vehicles from a central distribution point to as many redistribution points on his route, picking up the empty trucks on his return trip. These vehicles which were designed and built by Lloyd Wolf of Wolf Engineering Co., were described by Orville A. Brouer of Swift & Co. at **INDIANA SECTION** October 20.

THERE WILL NOT BE ANY IMPORTANT CHANGE in the type of motive power for passenger cars in this decade, according to A. T. Colwell of Thompson - Ramo - Wooldridge, Inc., who spoke at **ONTARIO SECTION** October 26.

The gas turbine, nuclear power, or such radical designs as the Wankel engine are not, in his opinion, going to replace the highly developed gasoline engine in its present form for a long time.

BOUNDARY LUBRICATION, the condition of lubrication where the fluid film does not separate the moving parts, is an unavoidable condition during some portion of the work cycle of most machines, and is, therefore, an important factor to be considered in designing bearings and lubricating mechanisms and in the selection of lubricants, Dr. F. S. Fein of Texaco Research Center told **TEXAS GULF COAST SECTION** on October 17.

— continued —

Rambling . . .

Through the Sections

— continued —

The TP25-2B AIR TURBINE DRIVE used in Lockheed C130 Airplane is examined by **METROPOLITAN SECTION** members who toured Stratos Division, Fairchild Engine & Airplane Corp. on November 1. They are (left to right) C. F. Branson, Aircraft Development Engineer, specialist, Georgia Division of Lockheed Aircraft Corp.; F. N. Dickerman, assistant chief engineer, Georgia Division, Lockheed Corp.; (SAE Member); E. E. Shube, (chairman, Long Island Meetings Committee for Metropolitan Section) chief of preliminary design, Stratos Division; C. S. Ryan, (Metropolitan Section chairman) E. I. du Pont de Nemours & Co.; and G. N. Jenkins, (meetings chairman for Metropolitan Section) Esso Standard Division of Humble Oil & Refining Co.

Michigan Tech's West Campus (at left), which includes 645 acres overlooking Portage Lake and the city of Houghton, Mich., offers four year courses in ten engineering curricula and other subjects. Tech's East campus, at Salt Ste Marie, Mich. offers first and second year courses paralleling the course offerings at Houghton, plus general college courses. (This is a correction of the caption appearing on page 99, September issue, SAE Journal).

The MODEL 3 CERLIST ENGINE, a new light weight, high speed diesel engine suitable for application in taxicab, light truck, and small marine installations, weighs only 605 lb with standard accessories, fan to flywheel, and produces 85 hp at 300 rpm, Robert White of Cerlist Diesel, Inc. stated at **NORTHERN CALIFORNIA SECTION**, October 26. Tests with the engine show fuel economy improvements from 50–100% over conventional gasoline powerplants. Precombustion chamber design utilized with the high compression ratio of 22 : 1 makes the lightweight engine relatively insensitive to grades of fuel.

The experimental 125 hp Scott R120 outboard engine, which was introduced to the Section's **SOUTH BAY DIVISION** by James L. Dooley and Joseph E. Leach of McCulloch Corp. on October 4, incorporates turbo-supercharger plus re-entry turbine and fuel-injection with two cycle design. At top speed the engine gets an estimated 17 hp boost from the supercharger. It also has forced feed lubrication to eliminate need for mixing gas and oil.

The importance of service and precision manufacturing in gaining good economy with high power to weight ratio diesel engines was stressed by Jin Thorten of Detroit Diesel, who instructed the Section's **SACRAMENTO-STOCKTON DIVISION** on recent developments in GMC line of diesel powerplants.

SHIELDING of the NUCLEAR REACTOR in the USS Triton on the first submerged circumnavigation was so effective that personnel were subjected to less radiation than those at home in normal surroundings, CDR James E. Stark, MC, USN, medical officer of the submarine told **SOUTHERN NEW ENGLAND SECTION**, October 1.

The extent of freedom from radiation was impressive: several of the personnel were divested of their wrist watches during the voyage as some of the supersensitive electronic devices on board were adversely affected by radon gas liberated from the dial faces.

Whether the negligible radiation was a contributing factor or not, it was observed that colds and similar contageous diseases, disappeared — in terms of contagion — within the first six weeks undersea. Besides maintaining a close watch for evidence of stray radiation, tests were made daily to detect or measure the value of 40–50 substances that could have been present within the liveable confines of the submarine.

SERVICE PERFORMANCE of a lubricant is related to a number of factors, the most important being the way in which the car is used. In short trip service, major problems are related to rusting or corrosion of critical engine

continued on p. 120

New England Section Members take Cruise

ANTI-SUBMARINE WORK was observed first hand by some 50 New England Section members on September 23 as they boarded the U.S.S. Wasp CV S-18 Flagship of Carrier Division 14 Task Group Bravo for a capsule study of the flexibility of Naval sea power.

The carrier embarked from Newport R. I. at 8:30 am and returned to Quonset, R. I. at 6:30 pm.

During the cruise, members observed the destroyer above refuel from the Wasp.

The captain's launch removing passengers from the Wasp.

Helicopter on the Wasp deck prepares for take off.

Looking towards stern of Wasp, SAE members (above) observe S2F planes line up for take off.

S2F plane taxiing to catapult.

Rambling . . .

Through the Sections

— continued —

parts. Severe engine rusting and excessive additive depletion can occur in only a few hundred miles, even when using acceptable lubricants. Some commercial MS oils permit excessive engine rusting in as little as 160 miles in severe short trip service.

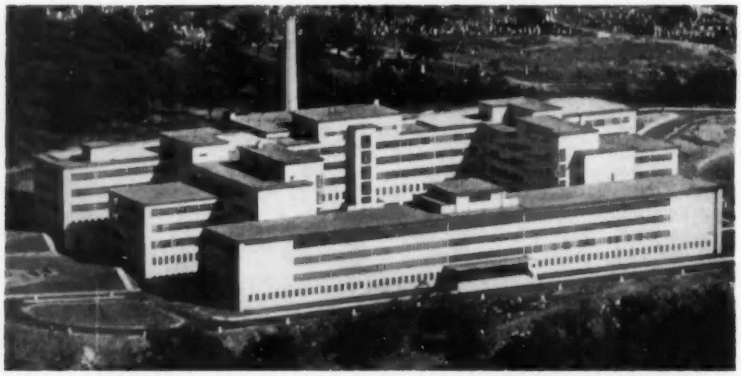
Alternately, representative lubricants will permit several thousand miles of operation without causing service problems in long trip service, where service problems are usually due to sludge and varnish deposition.

The significance of these differences is apparent when it is recognized that 80–85% of all passenger car trips are under 12 miles and 50% are less than four miles, Paul A. Bennett of General Motors Research Laboratories stated at **METROPOLITAN SECTION** on October 6.

ALUMINUM IS MORE than something to make pots and pans out of and wrap chicken in, William C. Weltman of ALCOA told **CENTRAL ILLINOIS SECTION**, September 19.

In the automotive industry there is a trend toward a unitized chassis-skin construction which eliminates dead weight in vehicles. This, along with advances in welding and fabrication technology, encourages use of aluminum alloys. Aluminum, in fact, appears to be capable of replacing steel as a vehicle fabrication.

W. E. MacKenzie (left) of Canadian Car Co., Ltd. receives first prize from W. S. Cowell of Albion Asbestos Packings, Ltd. at **MONTREAL SECTION'S** annual golf tournament which was held September 22.



Campus at Ecole Polytechnique

SAE at Ecole

IN TWO YEARS the French-speaking SAE Student Branch at Ecole Polytechnique in Montreal has grown from a 15-member SAE Student Club to SAE's third largest Student Branch. Its membership now totals close to 200.

Responsible for this astounding growth of student interest in SAE are:

1. An exhaustive 4-day recruiting program at the beginning of each school year, and

2. Establishment at the year's start of a full program of meetings, conferences, industrial plant visits films and other Branch-sponsored activities.

Backing and guiding the students in these efforts have been Guy L. Blain, Montreal Section 1958–60 vice-chairman for student activities, his successor for 1960–61, George Donato, . . . and Branch Faculty Advisor Maurice Poupard, an SAE member who is associate professor of mechanical engineering at the college.

4-Day "Crash" Program

The student-conducted recruiting campaign represents four days of intensive, concentrated activity. During those days SAE Enrolled Students take action on four fronts:

- They use cardboard posters, specially constructed exhibit stands, and public address systems to tell the SAE story throughout every area of Ecole Polytechnique.
- They put on paper the advantages of becoming an SAE Enrolled Student . . . in language appealing to fellow students. Then they reproduce many copies of that sheet of paper . . . and distribute it widely among Ecole Polytechnique's 1250 students.
- They invite all their fellow students to view a film devoted to an up-to-the-minute technical subject . . . and then invite them to attend an SAE Montreal Section meeting.
- They elect special representatives for each class, who makes themselves available to answer questions asked by non-members. (Each representative this year was briefed by Student Branch Chairman F. E. Morissette and Student Branch Secretary M. Langlois before being asked to face skeptics and questioners.)

The soundness of the program, coupled with the vigor and enthusiasm with which the Branch members carry it out combine to insure its success.

Definite Program Established

Equally stimulating to the Branch's rapid expansion of services at Ecole Polytechnique is the definite program of activities established and carried out each year.

During the 1959-1960 college year, for example, the Branch members was slightly over 30 films on various technical subjects. Some of these films were:

- "Strange Case of Cosmic Rays" —

SAE Enrolled Students use the facilities at the University's mechanical engineering laboratory.

Polytechnique

Bell Telephone Co.

- "Powered Flight" — Rolls-Royce, Ltd.
- "Advanced Welding Techniques" — Westinghouse Electric Co.
- "Operation Crossroad" — Westinghouse Electric Corp.
- "ABC of the Diesel Engine" — General Motors Corp.
- "ABC of Internal Combustion" — General Motors Corp.
- "Mining for Nickel" — International Nickel Co.

Industrial visits included trips to Shell Oil Co.'s Montreal East Refinery plant and to General Electric Corp. Speakers for the Branch's meetings and conferences during the past two years included: L. J. Shypenski of Canadair, Ltd., who discussed "The Rat", an all-ground vehicle designed and developed by Canadair; and P. Perriau of Societe d'Expansion Metropolitaine, whose topic was "A Pneumatic Buggy for Underground Vehicle."

MAURICE POUPARD is faculty advisor to the Student Branch at Ecole Polytechnique.

Poupard graduated from Ecole Polytechnique in 1953 and was an instructor in mechanical engineering at the University during 1953-1954.

After a year of teaching, he received an Athlone Fellowship and studied in England for a year.

In 1955 he returned to Ecole Polytechnique, where he is now associate professor of mechanical engineering.

Poupard

Student interest in SAE at Ecole Polytechnique was first aroused in 1950 through the efforts of SAE Montreal Section and Prof. R. Bouthillette of the University.

The Student club, formed with Prof. Bouthillette as faculty advisor, confined its activity chiefly to attending Montreal Section meetings. Then, in 1955, the Section invited a student from Polytechnique to present a technical paper at the Section's annual Student Night. For the next two or three years, SAE Enrolled Students from Ecole Polytechnique continued to present papers before the Montreal Section.

In 1956–1957 Prof. Maurice Poupard became faculty advisor to the club. Stepped-up club activity during 1958–1959 paved the way to the Student Branch Charter being officially granted on April 3, 1959. The charter was presented by A. H. Paton, past Montreal Section chairman to Prof. P. P. Vinet, Dean of Mechanical Engineering, who presented it to G. Perreault, 1959–1960 Student Branch chairman, at a regular Montreal Section meeting October 19, 1959.

About the School

Since its founding in 1873, Ecole Polytechnique has been prominent in the training of French speaking engineers. It has been an affiliate of the Université de Montréal since 1920 and could be regarded essentially as the engineering faculty of the University. It is, however, constitutionally separate, having its own board of governors and its own administrative officers. Through its contract of affiliation with the University of Montreal, it shares in the academic life of the campus and its degrees are given by the University.

The curriculum at Ecole Polytechnique includes a five year course in one of eight engineering fields: civil, mechanical, electrical, chemical, metallurgical, mining, geological, and physical engineering.

Among SAE members who are alumni of Ecole Polytechnique are: Guy L. Blain, superintendent, Operating Garages & Car Barns, Montreal Transportation Commission; Georges Donato, engineering assistant to superintendent of Cremazie & Youville Shops, Montreal Transportation Commission; Gaston Beauchamp, engineering executive assistant, Montreal Transportation Commision; Jean-Jacques Langlois, assistant engineering supervisor, Provincial Transport Co.; Jean Claude Lanoie, engineering superintendent, Dumont Express, Ltd.; Jean C. Paolucci, maintenance engineer, Montreal Transportation Commission; Bertrand Bouchard, assistant professor of mechanical engineering, Ecole Polytechnique; Claude De Guise, professor and chairman of drawing department, Ecole Polytechnique, and Maurice Poupard of Ecole Polytechnique.

SAE MEMBERS

PAUL M. NASH has been appointed manager of Chrysler Corp.'s Mound Road Engine Plant. Since last August, Nash has been quality control manager for the Power Train Group and prior to that he served five years as chief engineer for the Axle and Transmission Division.

DONALD P. DRIFTMIER has been appointed head of the newly established regional sales office at Hales Corners, Wis. for the Guide Lamp Division, General Motors Corp.

JULES C. LAEGELER has been appointed vice-president in charge of engineering at The Frank G. Hough Co. He was formerly chief engineer of the company.

Laegeler is an active member of SAE. He is a member of SAE Steering Committee on Construction and Industrial Machinery and a member of SAE Farm, Construction and Industrial Machinery Activity Committee.

ANCEL S. PAGE has been elected vice-president of Dura Corp. He is also general manager of Page & Page Co., which was acquired by Dura in August, 1960.

A. L. SPURLOCK has been named vice-president and general manager of the Leukart Machine Co. Spurlock was formerly manager of manufacturing engineering at Aviation Gas Turbine Division, Westinghouse Electric Corp.

IVAN N. SCHATZKA, senior project engineer at Willys Motors, Inc. has been named chief experimental vehicle engineer of the company.

PETER H. PONTA has been appointed director of a newly created organizational unit known as the manufacturing engineering and development office of Ford Motor Co. He was formerly director of the manufacturing engineering office.

HAROLD N. BOGART has become assistant director — manufacturing development, reporting to **Ponta.** Bogart formerly was manager of the process development department of the manufacturing research office.

J. KENNETH HAMPTON has retired as manager of the Washington office for the Detroit Diesel Engine Division of General Motors Corp. Although retired, Hampton will be retained by Detroit Diesel as a consultant.

WILLIAM J. McTIGHE has been appointed vice-president and general manager of Wheeler Service, Inc. of Cambridge, Mass. McTighe recently resigned as sales manager, Special Division of The Bunting Brass & Bronze Co. of Toledo, Ohio.

HOWARD D. BROWN, formerly with the General Department of the American Telephone & Telegraph Co., is now consultant to Highway Trailer Industries, Inc.

THOMAS A. MARSHALL, JR. is American Society for Testing Materials' new executive secretary.

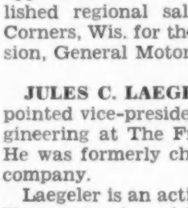
Marshall came to ASTM from American Society of Mechanical Engineers, where he had been in charge of the Editorial, Research, and Meetings-and-Divisions Departments.

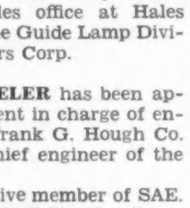
After graduation from Georgia Institute of Technology in 1932, Marshall started his career with Metropolitan Life Insurance Co., and rose to the position of Senior Procedure Analyst, in the Management Research Division. In 1951, he was executive secretary of Engineers Joint Council's Engineering Manpower Commission. He left Engineers Joint Council in 1954 to become a member of ASME's staff.

Illness caused the resignation of R. J. Painter, ASTM's executive secretary since 1952. Painter continues with ASTM as a consultant.

WILLIAM R. CAREY is now project engineer at Dura Corp. Formerly he was product engineering designer, Ford Motor Co.

ROBERT F. STEENECK has retired from Fafnir Ball Bearing Co., for which he was regional manager in Cleveland for many years. He has built a new house in Escondido, California, where he will live. Steeneck is a Past SAE Director, was chairman of the Cleveland Section, and played a major role in the establishment of the SAE Production Forums which has been so successful throughout the last 15 years.


Nash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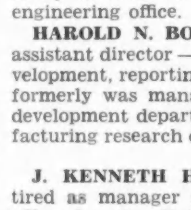
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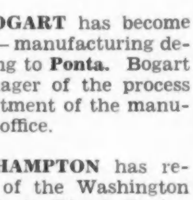
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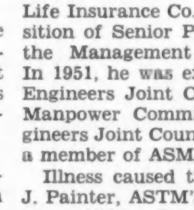
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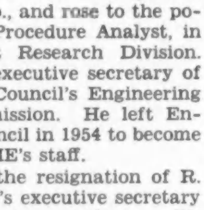
Schatzka

CHARLES F. THOMAS has been appointed to the newly created post of manager of marketing and planning for the Radio Corp. of America's major defense systems organization.

Thomas joins RCA following 25 years as a leading engineering and contracting executive of the Lockheed Aircraft Corp. He had been serving as the aircraft firm's director of military sales.

HENRY D. HUKILL has retired from Bendix Corp. after 31 years of service. Hukill first joined SAE in 1923, when he was manager of automotive power brake activity for Westinghouse Air Brake Co. He was one of the pioneers in development of present day automotive air brakes, including some 25 patents and several technical papers in this field.

PAUL B. HARTMAN, chief experimental engineer for Willys Motors, Inc., has been named to the newly created position of chief military engineer. He will work closely with the U. S. Army Ordnance Corps and other military units.

C. M. SHEPSTONE, formerly sales representative for Warner Electric Brake & Clutch Co. has been appointed sales engineer for Dana Corp.'s home office in Toledo, Ohio.

DANIEL APPLEGATE has recently been designated project engineer for the Convair 880 program, San Diego Division of General Dynamics Corp. He was formerly project Engineer for the F-106 program.

EUGENE J. ZIURYS has joined Thompson-Ramo-Wooldridge, Inc. as a consulting engineer in the preliminary design department of Tapco Groups' New Devices Laboratories. He comes to Thompson-Ramo-Wooldridge from General Electric Co.'s Aircraft Nuclear Propulsion Laboratory where he has been principal engineer for advanced design.

DENIS J. BRACKEN has been appointed general manager of the Automotive Assembly Division, Ford Motor Co. Formerly he was general manager of Ford Division, Ford Motor Co.

PAUL A. PITT has been elected vice-president-engineering of Solar Aircraft Co., a subsidiary of International Harvester Co. He was formerly Solar's chief engineer.

University of Michigan Honors H. E. Chesebrough

SAE President HARRY E. CHESEBROUGH, vice-president of Chrysler Corp., general manager of the Plymouth Division was recently awarded an "Outstanding Achievement Award" presented by the University of Michigan to alumni who have distinguished themselves.

The award cites Chesebrough as an "outstanding automotive engineer and executive."

The citation says in part, "His judgment as an industrial executive is as highly regarded as his scientific and technological acumen. It is a fitting token of the solid technical basis of his career that he should now be serving as national president of the Society of Automotive Engineers."

Following the ceremony at which he received the award Harry E. Chesebrough (above center) chats with University of Michigan President Harlan Hatcher (left) and Stephen S. Attwood, dean of the College of Engineering.

B. GRATZ BROWN has joined the engineering staff of McCord Corp. He will direct product engineering at the Equipment Gasket Division at Wyandotte. Brown was formerly automotive development engineer at Sterling Aluminum Products, Inc.

J. E. BEACH, an SAE Enrolled Student, took part in the first annual Western Leadership Conference of the Junior Technical Engineering Society, a national industry-sponsored organization designed to assist high school and junior college students in the exploring of engineering careers.

Beach represented the SAE of Whittier.

JOHN M. CHAMBERS has resigned his position as chief agricultural engineer, Europe, with Massey-Ferguson in order to become a consultant. As a consultant he will specialize in farm, horticultural, estate and forestry machinery and also in industrial machinery.

ROBERT M. LYNAS has been named operations manager of the Michigan Division of Thompson-Ramo-Wooldridge, Inc. with responsibility for the Van Dyke, Portland, and Federal Works. Formerly he was manager of the Michigan Division.

Continued on page 125


Thomas


Hukill


Hartman


Shepstone


Applegate


Ziurys

SAE Members

Continued from page 123

Hufnagle

LaMontagne

Holdeman

EDWARD W. HUFNAGLE has become manager of automotive sales for the Glass Division of Pittsburgh Plate Glass Co. He was formerly assistant manager of automotive glass sales.

ELLIOTT LaMONTAGNE has been appointed manager of the After Market Division, Cole-Hersee Co. He was formerly sales representative, American Bosch Division, American Bosch Arma Corp.

JOHN W. HOLDEMAN has been appointed vice-president-engineering of Warner Automotive Division of Borg-Warner Corp. He was formerly associate director-Automotive Department at the Roy C. Ingersoll Research Center of Borg-Warner.

Obituaries

CLYDE A. CROWLEY . . . (M'36) . . . chairman, department of chemistry, Arizona State University . . . died September 21 . . . born 1902

ROBERT W. EDWARDS . . . (M'53) . . . president, The Edwards Motor Transit Co., Inc. . . . died October 15 . . . born 1920

JAMES E. LYLE . . . (M'58) . . . manager, engineering, International Harvester Co. of Mexico . . . died September 5 . . . born 1901

IRVING J. MACK . . . (M'49) . . . vice-president, AGA Division, Elastic Stop Nut Corp. . . . died September 5 . . . born 1906

JAMES EDWARD McLEAN . . . (M'49) . . . vice-president, engineering, research and development, Stubnitz Green Corp. . . . died May 20 . . . born 1902

Continued from page 94

filter paper or as having an effective pore size of 10 microns.

The effective pore size is difficult to measure microscopically on reinforced paper media and, hence, tests similar to those described above have been performed upon wire mesh media whose pore size could be optically determined. It was noted that the experimentally determined pore size using the glass bead method coincided well with the microscopically evaluated pore of the mesh. It is possible, therefore, to state that the effective pore size of a reinforced paper medium determined by the glass bead disc method is equivalent to the dimensions of a rectangular or square screen mesh having the same surface filtration characteristics of the test medium.

■ **To Order Paper No. 223B . . .** from which material for this article was drawn, see p. 6.

Trucks to Match New Roads in Offing

Based on paper by

J. C. WAGNER

International Harvester Co.

TRUCK design will be greatly influenced by the super highway system now being built. We are already moving rapidly toward truck trains for long hauls, gas turbines are being considered for powerplants, and containerization is under experimentation.

The so-called, double-bottom or combination unit is being run experimentally and sucessfully in several states. It comprises two 40-ft trailers in tandem behind a diesel-powered tractor of 335–375 hp. With a gcw in the 130,000-lb range, it is capable of 50-mph speeds on the level and 20 mph on 3% grades, proving that 100-ft truck trains can share the new roads with passenger cars.

Gas turbines are front-running candidates for powering the new truck trains, since the size and weight of diesels would be limiting factors if the new roads permit lengths and weights beyond double-bottoms for future truck trains. Turbine producers are talking of turbines in the 500–800 hp range with a life cycle equal to or better than that of conventional diesels and less costly to maintain.

If the individual units of the trailer train were to be self-propelled and remotely controlled from the lead unit, the power problem could have another solution. Smaller engines could then be used. Furthermore, the units could be disconnected at terminals to proceed under their own power over secondary roads.

Another logical step along the route of gaining greater flexibility in highway

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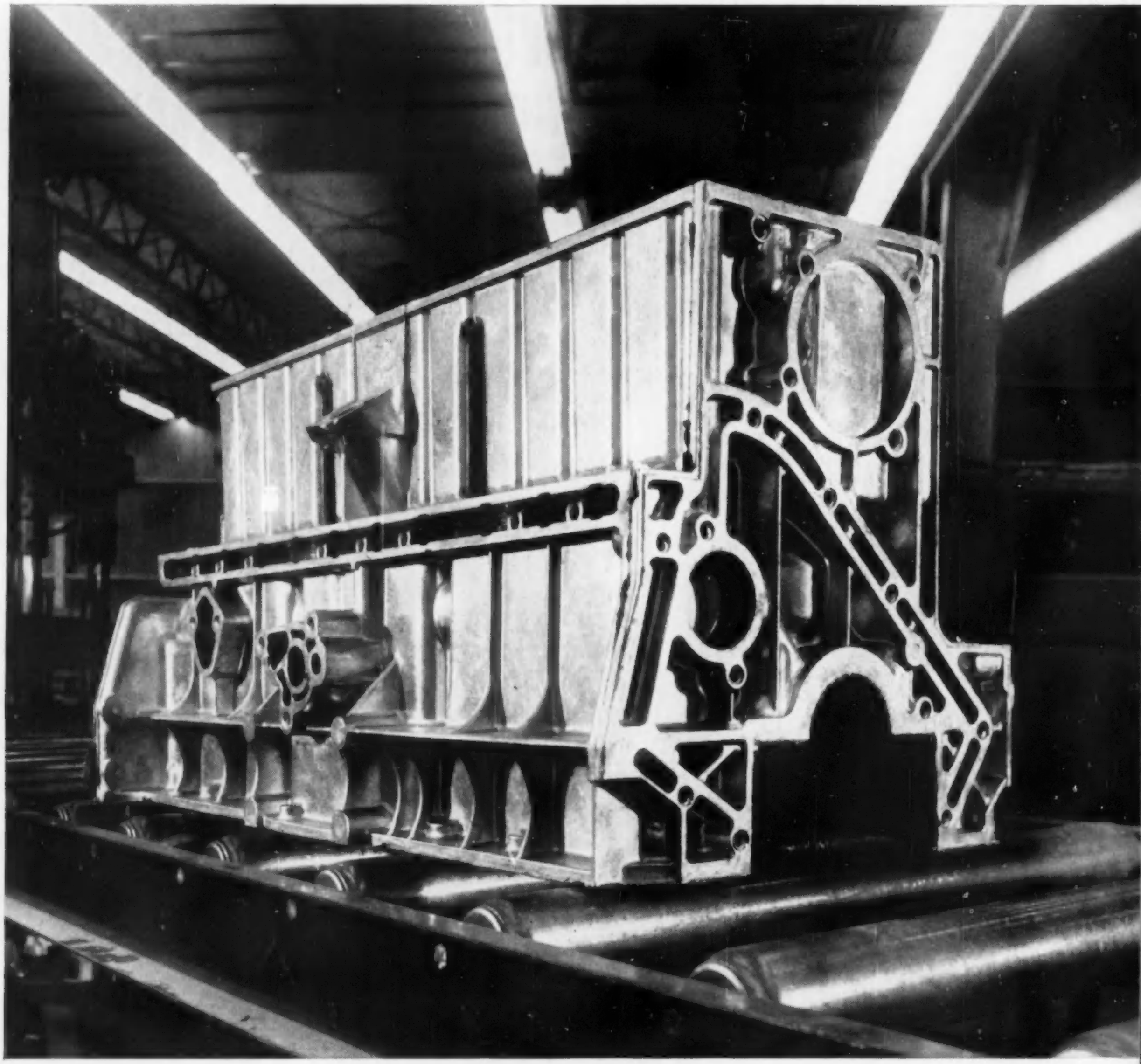


World's first die-cast aluminum "six"

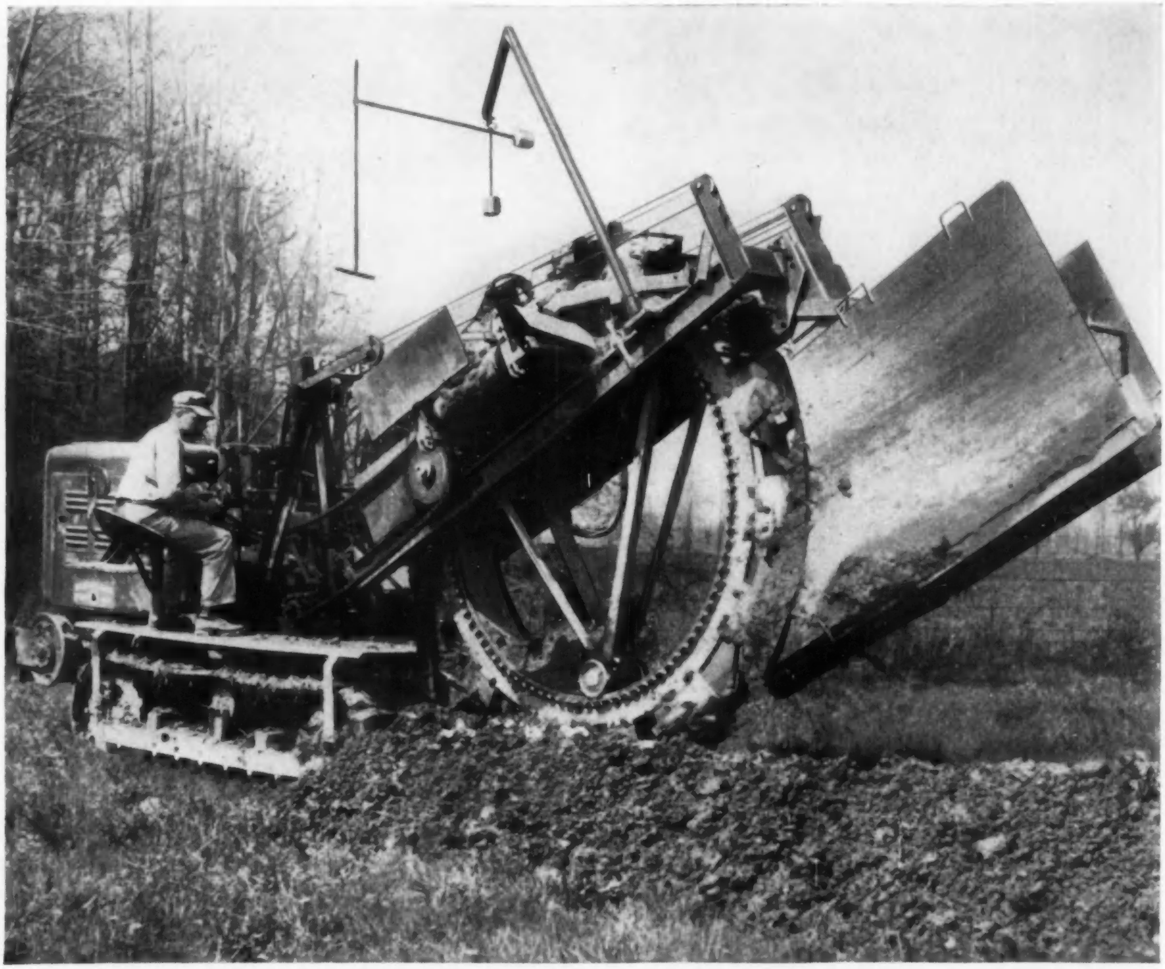
Saves 80 pounds for American Motors' new Rambler Classic . . . incorporates specially bonded cast iron liners in dry sleeve design.

This engine block is the biggest die casting ever mass produced. It's the world's first six-cylinder block for passenger car use to be die cast in aluminum.

It's a 67 pound lightweight including 14 pounds of centrifugally cast iron cylinder liners. That means a total saving of 80 pounds deadweight . . . now standard in the new Rambler customs, optional in other Rambler models.

Light but strong. The excellent physical properties of aluminum are fully utilized by careful die cast design and scientific photostress analysis to build outstanding strength and internal soundness into the end product.

BMI bonding is simple and sure. The BMI—or Bi-Metallic Interlock developed by Doehler-Jarvis—mechanically "anchors" the liners by means of their specially prepared cast surfaces. Since these liners are centrifugal castings, no knurling, crimping or splining is needed. An intimate locking action occurs as the molten aluminum is injected into the die . . . under 8,000 psi. The result: an inseparable bond with excellent heat-transfer properties. The Bi-Metallic Interlock bond is the subject of a pending patent application.



Continued from page 127

transportation would be to adopt containerization. Containers could be made interchangeable between all modes of transportation — highway, rail, air, and water. Containerization combined with the truck train could help to shape the trucks we'll be seeing on the super highway system in 1975.

■ **To Order Paper No. 284B . . .** from which material for this article was drawn, see p. 6.

Film Aids Hot Fuel Performance Studies

Based on paper by

W. A. GARTLAND
Ford Motor Co.

HOT FUEL handling performance on the road can be reproduced on a chassis dynamometer, provided primary fuel temperatures and repeatable performance data are first established on the road and are closely correlated on the dynamometer. Motion pictures can then be taken for visual investigation of hot fuel behavior under actual operating conditions.

In studies conducted by Ford, the 1958 CRC Volatility Program showed good repeatability and with slight modification toward more severity it proved to be ideal for establishing the necessary road information. These studies showed it to be advisable to use the same vehicle for road and chassis test work. It was also found vital for chassis dynamometer correlation to record all temperatures for one mile prior to the soak period to establish warmup temperatures, and during the entire soak period to obtain soak conditions.

■ **To Order Paper No. 264C . . .** from which material for this article was drawn, see p. 6.

Enjay Engine Test Speeds Oil Formulation

Based on paper by

HAROLD E. DEEN and
ALAN A. SCHETELICH
Enjay Laboratories

THE engine test was designed specifically to predict the Caterpillar L-1 test performance of lubricants. It does so in less than one fifth the time required by the L-1 test.

The time-saving feature of the test is important because changes in lube oil processing can be appraised rapidly, the proper concentrations of additives to meet given performance targets can be determined quickly, and new additive formulations can be evaluated and developed with dispatch.

A modified Witte Series 38 engine is used. This is a vertical, single-cylinder, 4-stroke power unit. When run under specified test conditions it produces piston deposits strikingly similar in type, location, and amount to those obtained in the L-1 test. The standard test time is 90 hr. The test may be run at a high or low fuel sulfur content to correlate with either the MIL or Supp. I test conditions of the L-1. The low sulfur content is 1%, which corresponds to the 0.35% sulfur MIL-2104A conditions. The high sulfur content is 2%, which corresponds to the 1% sulfur MIL-2104A Supp. I conditions. The increased severity obtained from the higher sulfur fuels in the Enjay test permits the shorter test time. The test is reproducible.

Each test requires a total of 10 lb of oil, which contrasts very favorably with the 45 lb required for an L-1 evaluation. In addition, the initial unit cost and individual test cost are considerably below L-1 costs.

■ **To Order Paper No. 263C . . .** from which material for this article was drawn, see p. 6.

Battery APS Best For 2-min Power Needs

Based on paper by

DAVID T. A. MILLER

Whittaker Controls Division,
Telecomputing Corp.

IT is not surprising that the silver-zinc battery enjoys considerable popularity as an auxiliary power system for expendable rocket boosters — where the power requirement is for less than 20 hp for one or two minutes.

This battery-type APS is versatile and requires a minimum of development time. Also, it is the only one of four potentially likely systems that doesn't have a major envelope dimension specified by the properties of the energy source . . . the radius of the flywheel, length of the solid-propellant grain, or radius of the bottle, for example.

The flywheel APS, the solid-propellant APS, and the bottled-gas APS, recent Whittaker analyses indicate, all have major disadvantages.

The flywheel and the solid-propellant APS, for example, cannot be applied satisfactorily to a wide range of duty cycles, though they do provide extremely good performance when restricted to favorable load requirements. The bottled-gas APS is entirely unsuitable. It is excessive in weight and size, and, in addition, involves a relatively complex energy conversion system.

■ **To Order Paper No. 232A . . .**
from which material for this article was drawn, see p. 6.

Better Filters Needed For Hydraulic Systems

Based on paper by

H. L. FORMAN and C. J. CASALEGGI

Purolator Products, Inc.

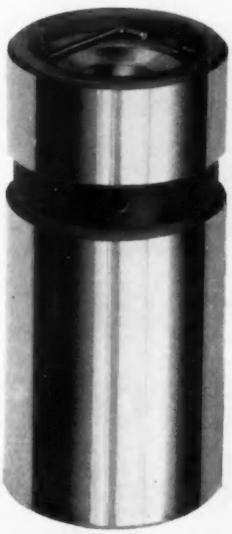
AS TEMPERATURE REQUIREMENTS of hydraulic systems increase to 300 F — and higher — both reinforced paper surface-type filter media and edge-type surface filters must be improved. Reinforced papers in the surface filters, for example, must be replaced by the newer, stronger media made of nonwoven nylon, dacron, or orlon.

The number and size of the pores larger than the nominal pore size of the surface media, whether paper or nonwoven synthetic fabric, must be reduced, so as to impart to surface media more narrowly controlled filtration properties. By thus reducing the size of the largest particle capable of passing through the medium, more reliable filtration protection will be afforded the user.

In addition, better filter element adhesives must be developed. These are needed for use with the more exotic fluids already finding greater use — as operating temperatures increase — due to their superior nonflammable properties, greater lubricity, and higher viscosity indexes. Research in the improvement of these cements is going on, seeking hydraulic fluid resistance over a range from – 65 to 350 F.

Several manufacturers have developed new Dutch twill stainless-steel mesh surface filters. These are designed to meet demands of the missile industry for clean, strong, compact hydraulic filters allowing passage of no particles larger than 15 microns. The cost of these filters is high, in comparison with reinforced paper surface-type filters, or even the nonwoven synthetic fiber media. But the knowledge gained in the past three years in their development is leading to improvement of conventional filters.

■ **To Order Paper No. 223B . . .**
from which material for this article was drawn, see p. 6.



New Members Qualified

These applicants qualified for admission to the Society between October 22, 1960 and November 22, 1960. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group: William A. G. Everett (A).

Atlanta Section: Wellington H. Force (A), Parker Little (M).

British Columbia Section: Gerard Doeksen (J), William Peter Inge (A), C. J. Makin (A).

Buffalo Section: Joseph A. Grom (M).

Central Illinois Section: Jack Wayne Carter (J), Richard P. Larence (A), Robert LeRoy McNabb (J).

Chicago Section: Harvey Wm. Gordon (J), Richard K. Hedlund (J), Earling C. Johnson (A), Karel Klima (M), Robert G. Lofgren (J), David Edward Thorn (M).

Cleveland Section: David L. Huntsberry (A), Richard A. Janssen (J).

Colorado Group: James Richard Santangelo (J).

Dayton Section: Alvin Clinton Forsythe (J), Gordon Sterling Mead (M), Gerald M. Sturm (J).

Detroit Section: Richard P. Averill (J), Leland W. Beck (M), Richard N. Burns (J), Edward Oliver Cascardo (J), R. Scott Daugherty (A), Robert Carl Dodt (J), Warren F. Haberkorn (A), Robert Frederick Hess (J), Thomas Anthony Killewald (J), Robert Lloyd Mentzer (J), Vacys Z. Mitkus (A), James C. Mock (J), Martin J. Pattyn (M), Raymond C. Randel (J), James Cleophile St. Amand (M), James F. Schmitt (M), Ernest Secules (A), Everett H. Sharp (M), Robert H. Sims (M), Stanley Ewald Staffeld, II (M), John E. Sullivan (M), Rex Keith Tolle (J), Donald Marvin Waltz (J), Ronald R. Wisner (J).

Fort Wayne Section: Raymond Charles Valentine (J).

Indiana Section: Joseph John Clegg (J), James Ross Williams (J).

Kansas City Section: Boyd L. Freels (A), Robert Arnold Stinson (A).

Metropolitan Section: Edward Heinzelman, Jr. (M), Frederick M. Jackson, Jr. (J), Gottlieb Koenig (J), Wilson Kokalari (J), Arthur Noble Kugler (M), Frank Warren Oswald (A), Robert Lincoln Pike (M), Daniel Poryles (A), W. Wallace Sellers, Jr. (M).

Mid-Continent Section: Richard Charles Hall (J), James Leroy Jones, Jr. (J).

Mid-Michigan Section: W. H. M. J. Vander Horst (J), Edwin D. Weddington (J).

Milwaukee Section: Thomas William Baehler (J), Leonard John Hunsader (J), Arnold Herbert Janot (J), Eugene J. Musbach (A), Eugene Pramenko (J), Edmund Rostkowski (A), Paul Joseph Welz (J), Fred August Ziegler (J).

Montreal Section: Bryan Thomas Baker (A), Pierre-Emile Bonin (J), John Stewart Farley (J), Gaetan Morin (A), Fumio Motomura (J), Ian Rutter (J), Gerald Albert Suek (J).

New England Section: Peter E. Glaser (M), Thomas M. Toppin (A).

Northern California Section: Robert Warren Armstrong (J), Paul Nelson Price (J), Dwight Emerson Robertson (J).

Northwest Section: Ronald Gene Lenz (J), William Fred Pieper (J).

Ontario Section: Sydney Leon Britton (M), Merlyn Eugene Cranston (J), Albert Michael Hand (J), Lubomir Charles Hykel (J), George A. Lacy (M), William Warren Nesbitt (A), William Cecil Patterson (J), Jack Simpson (A), Peter Ronald Trollope (A), Andrew H. Yamanaka (M).

Philadelphia Section: J. B. Curcio (A), James H. Currie (J), Richard Carl Duehne (J), John W. Hannell, Jr. (M), Samuel R. Mami (J), John Anthony Marino (A).

Rockford-Beloit Section: Robert Hilton Shoquist (A).

St. Louis Section: John Douglas Bartley, Jr. (J), Glenn E. Borgard (J), Jerome Adelbert Galiley (J), Walter Franklin Powell (J), Robert Eugene Thompson (J).

Salt Lake City Group: Charles Edward Wiemers (J).

San Diego Section: Douglas Larry Bledsoe (J), Laurence Richard Fusselman (J), Charles Maynard Richards, Jr. (M).

South Texas Group: S. Ray Bell (A).

Southern California Section: William Pitts Baxter (M), Clifton J. Chandler (A), Wilson James Elder (J), Edwin N. Friesen (J), Jakob K. Jakobsen (M), Alfred B. Killebrew (M), Harry T. Linde (A), Floyd Eugene Robinett (J), Don David Sampson (J), Jerome Warner Thompson (J), Thomas M. Wambaugh (J), Kiyoshi Ernest Yamane (J).

Southern New England Section: Joseph Serrin Nelson (M).

Syracuse Section: Terrance Michael Hebert (J).

Texas Gulf Coast Section: Boris K. V.

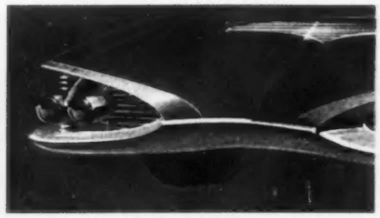
Continued on page 143

Aluminum Trim

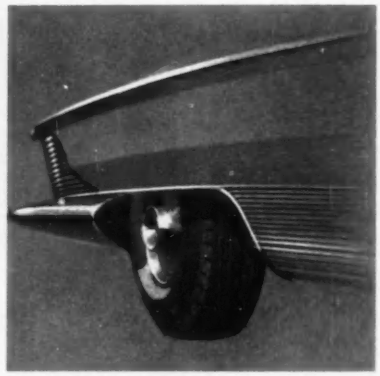
combines lasting,
sales-appealing beauty
with fabricating and
finishing economy

Exterior Trim

WINDOW AND PILLAR MOULDINGS

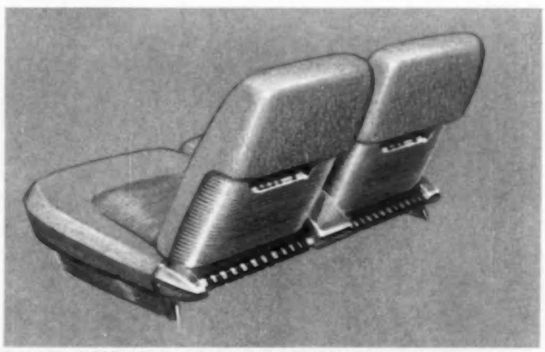


GRILLE AND GRILLE MOULDINGS

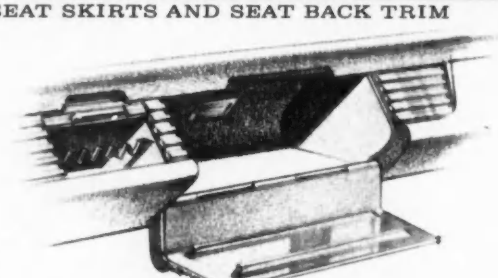


SIDE MOULDINGS

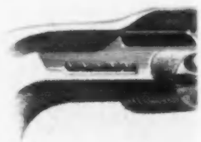
Interior Trim

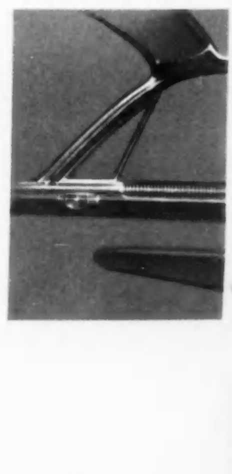


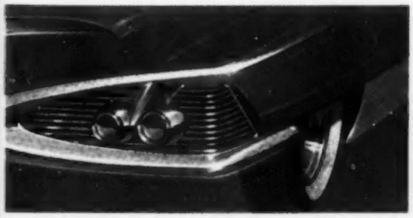
SEAT SKIRTS AND SEAT BACK TRIM



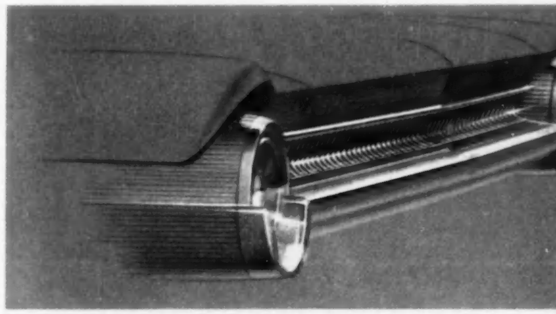
ASH TRAYS AND COVERS—
GLOVE BOX DOORS



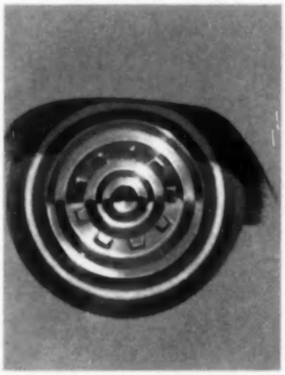




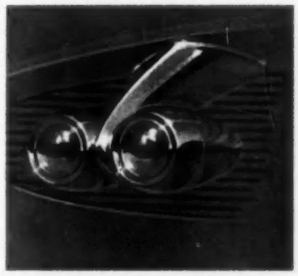
WINDSHIELD AND
ROOF MOULDINGS



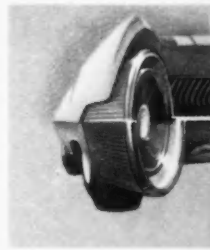
REAR BUMPER OR DECK TRIM—
QUARTER PANEL APPLIQUES



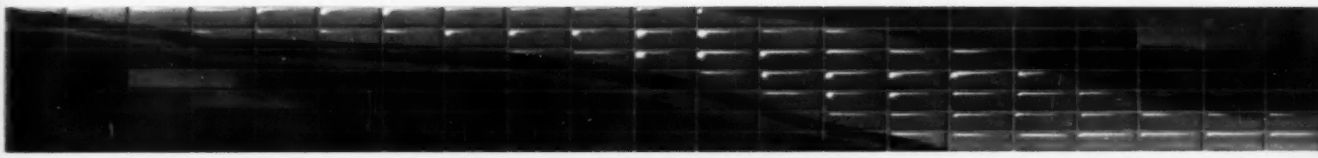
HUB CAPS—WHEEL
COVERS

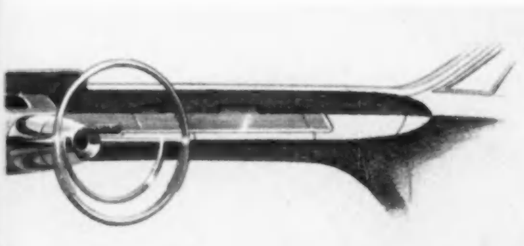


HEADLAMP BEZELS

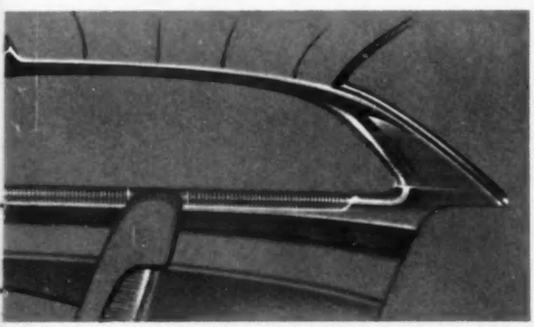


TAIL LAMP
HOUSINGS

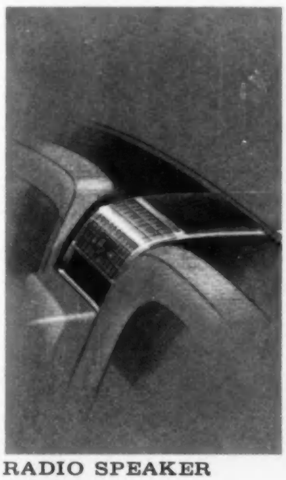




INSTRUMENT PANELS AND TRIM

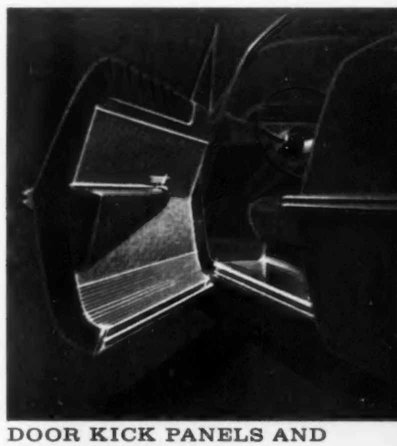


WINDOW MOULDINGS—
PILLAR COVER TRIM

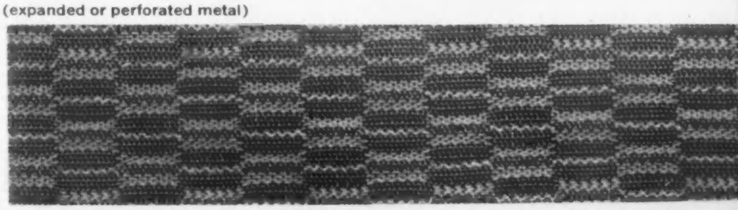


RADIO SPEAKER
GRILLE

(expanded or perforated metal)



DOOR KICK PANELS AND
SCUFF PLATES



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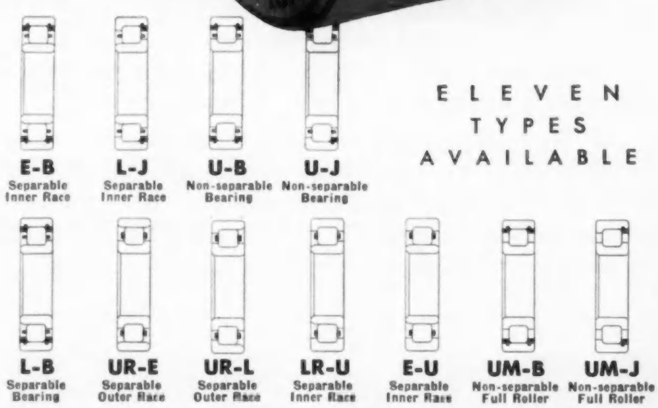

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. . . continued from p. 135 . . .
Danielowsky (A), Richard S. Manne (M).

Twin City Section: Kenneth H. Rice (M).

Virginia Section: Neil W. Zundel (A).

Western Michigan Section: Norman Edward Overway (J), Donald L. Swards (J), Lawrence Van Elzelingen (A).

Wichita Section: William E. Watts (A).

Outside Section Territory: Donald E. Berge (J), Richard Jay Clarke (J), Donald S. Demo (J), Wilson Hoag, Jr. (J), Calvin Neil Moulton (J), Lyle Dean Six (M), Donald James Slattery (J).

Foreign: John Owen Dewan (M), West Australia; Carlos A. Weil (M), Argentina.

Applications Received

The applications for membership received between October 22, 1960 and November 22, 1960 are listed below.

Alberta Group: Glenn Henry Shire, Alexander Kudryk

Atlanta Section: R. G. Cavanaugh, W. P. Frech

Baltimore Section: Carl Stanley Weinberger

Buffalo Section: Cecil E. Angell

Central Illinois Section: William D. Brandon, Dewey Charles Fitch, Francis Alan George, Harold V. Towles

Chicago Section: Mathew J. Alagna, Clifford D. Brauck, Theodore H. Clark, Robert F. Davis, George T. Fiala, Jimmie Lee Hasten, Richard F. Little, Ray F. Notz, Donald A. Piepho, William J. Ries, William Norman Schink, Vincent J. Sloma, Duane R. Smith, William G. Stilke, Carson J. Ward, Harold R. Watson

Cincinnati Section: Jack Chambers, John Joseph Dooley, William Nickels Marquard

Cleveland Section: Wells E. Ellis, Reynold Gamundi, Paul Nierman Jaroch, Warren Krause, Louis Lichi, Merlin J. Miller, David E. Neustadt, Edgar Gauch Parks, Jr., Anthony John Riccio, Scott Weaver

Dayton Section: Roland Lee Kesler

Detroit Section: Robert Harvey Alfred, Richard Thomas Amsden, James Edwin Benjamin, James Reed Brown, Roger Edward Brown, Julius A. Chelenyak, Paul R. Blecki, Alan E. Carlson, Paul Martin Chellberg, Walter H. Dallas, Charles Albright Feeser, Douglas E. Foeller, Arie Groeneveld, Benjamin Willis Harrison, George E. Henry, Leo J. Kevitt, A. Donald Laudani, J. E. Leidgen, C. Carl Marcucci, Alexander Hing Mark, Frank T. Melcher, Robert Walter Militzer, Louis M. Millon, Henry Petri, Louis Jerome Sciez, Gene L. Scofield, Richard Kenneth Shier, Thomas Allen Skemp, James Knox Slinger, Jack J. Somma, Donald Beverly Wilson

Fort Wayne Section: Jack I. F. Davis, Louis Michael Hajmast, James G. Hoelle, John B. Mason, Donald Gene Murphy, Jerry D. Bolds

Hawaii Section: Richmond Kaliko Ellis, Jr., Richard D. J. Lee

Indiana Section: Richard M. Coulter, Charles T. Flatt, Daniel William Patton, John E. Storer, Jr.

Kansas City Section: Lawrence Conrad Bender, Gene S. Hendricks

Metropolitan Section: André Thomas Abromaitis, Eric Swire Bates, Gerald S. Fields, Randall Wayne Johnson, Kenneth H. Kirgin, Edward O'Hearn Leahy, Jr., Ivan Pour, Theodore Christopher Sauer, Wesley Dennis Turner, Fred W. Wallsteiner

Mid-Michigan Section: Arthur William

Continued on page 144

. . . continued from p. 143 . . .

Henke, William E. Pearson, Jerry Myron Roethlisberger, R. Michael Tucker

Milwaukee Section: Thomas Henry Hock, Richard Harold Shafer, Usama Salem Namik

Montreal Section: Thomas Edward Barff, Edward Henry Carroll, Jacques Donato, Bernard Labelle, Lionel Kenneth Jones

New England Section: Louis V. Tomasetti

Northern California Section: John Patrick Sloan, George Urban Brennan, Robert Palmer Miller, Joseph A. Rau, Richard Stanley Shaw, John J. Weaver

Northwest Section: Harold Guy Edwards

Ontario Section: Zigmond deGalocsy, Hans G. Reichmann

Oregon Section: Donald William Keller

Philadelphia Section: John Francis Clark, Milton Ginsburg, Ralph Porsia

Pittsburgh Section: James Milton Arnold

Rockford-Beloit Section: James H. Fraser, Martin T. Laffey, William J. Storey

Salt Lake Group: Alan Thomas Rowe

Southern California Section: Joseph Lawrence Albus, Boris Borisoff, Louis C. Carlin, Bernard Hier, C. K. LeFiell Kirke Leonard, Ralph Henry Rudd, Joseph L. Schroeder, Clifton Thomas Williams

Southern New England Section: Charles Francis Paquette, F. Richard Wocasek

Spokane-Intermountain Section: Robert H. Benesch, Donald Chas. Cochrane

Syracuse Section: Robert James Donaldson

Texas Section: John Carroll Boteler, Frank William Dillingham

Twin City Section: John Forrest Anderson, Ambrose D. DeGidio, Howard M. Pollari

Western Michigan Section: James Hugh Boyle, Raymond J. Green

Outside Section Territory: Alb C. Ballauer, Frank James Hems, Norman F. Lemmon, Robert Lloyd Schmidt

Foreign: Hector Ricardo Bunge, Argentina; Thandi Subbarayalu Dhanapalan, India; Giovanni Francesco Francia, Italy; John Giles, England; Ramon Guillen, Mexico; Clayton A. Ildza, Argentina; Captain Jaswant Singh Maun, India; Hector Melo, Mexico; K. Rajendren, India; George W. A. Stones, Libya; Captain Gurbux Singh, India; Jacobo Olegnoqicz W., Mexico

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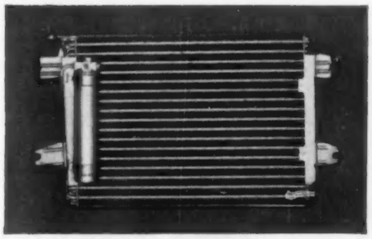

A typical tube and fin-type Harrison Air Conditioning Condenser with attached receiver-dehydrator. Its compactness, sturdiness and reliability make it ideal for automotive application.

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Mass production and strict quality control are important parts of our business, naturally. But even more important, we feel, are the independent solutions to your problems which our engineering and metallurgical staffs produce to further serve you. As another step to maintain this service, Sealed Power recently opened the newest and finest research and technical center in the piston ring industry.

Sealed Power is also noted for breakthrough engineering achievements which serve the entire industry. One such advance is our Stainless Steel oil ring—now widely accepted by the automotive segment of the reciprocating engine industry. This, and all Sealed Power contributions, are dedicated to our common cause—improving and refining the efficiency of the reciprocating engine.

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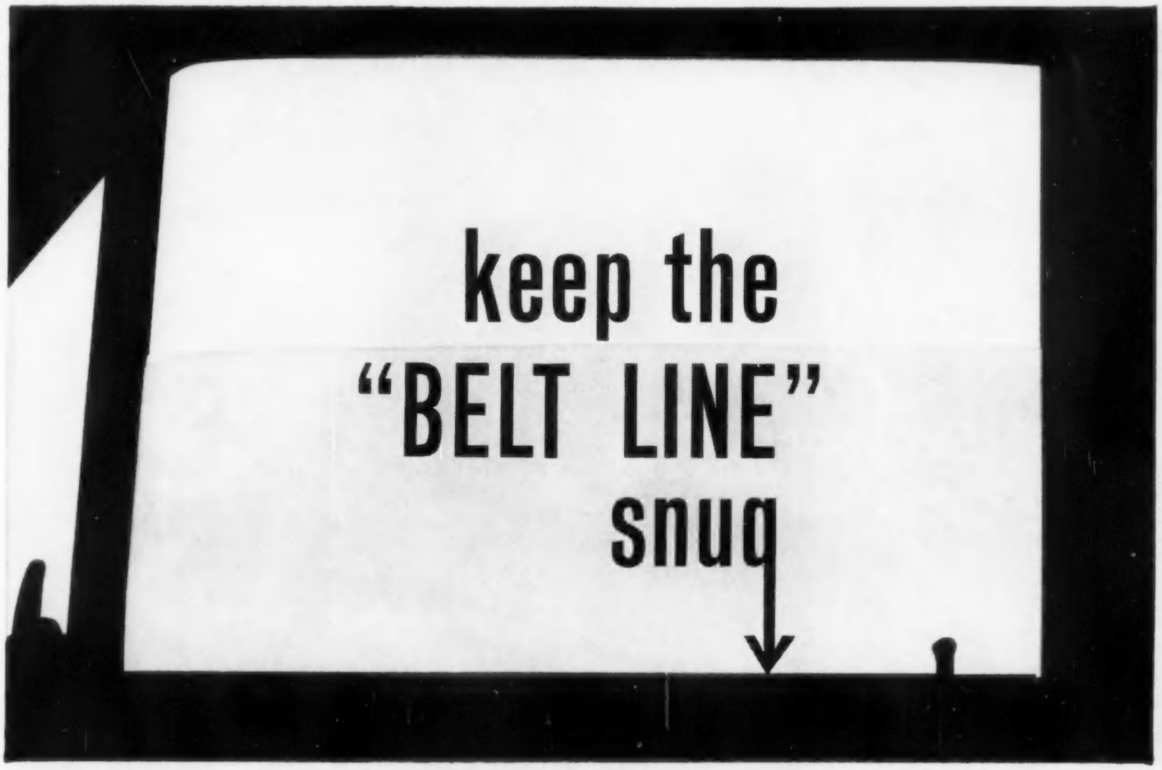

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Here, at the "belt line" of a modern automobile window, a weatherstrip must snuggle closely against the glass, sealing out dust and moisture. But the seal can't be so tight that the glass doesn't move easily.

This is where you need the extra resilience of Schlegel weatherstrip pile.

See how the individual strands of yarn in Schlegel pile bend against the glass surface? Their natural resilience keeps the glass firmly in place, holding an effective seal for the life of the automobile. It compensates for even the widest manufacturing tolerances.

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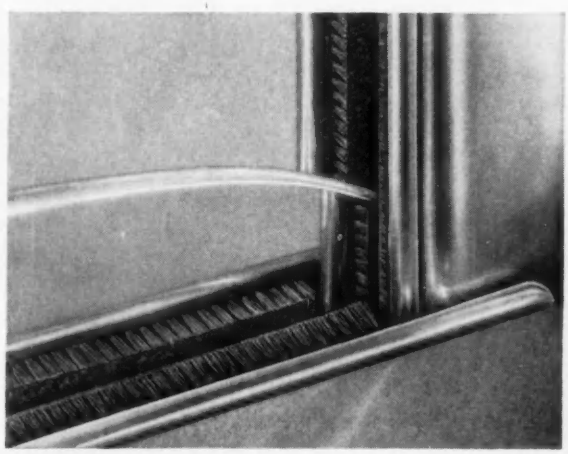
To you, the extra quality we build into Schlegel pile means easier window movement; rattle-free, trouble-free windows; better sealing qualities—and complete dealer and customer satisfaction.

See what Schlegel woven pile can do for you. Check a sample in your wear-testing lab. When you specify glass run channel or belt strip assemblies, be sure to specify Schlegel woven pile liner—favorite of the industry since glass windows were first used in cars.



Glass moves friction-free, wet or dry, in this glass run channel with Schlegel woven pile liner.

Schlegel

SERVING THE AUTOMOTIVE INDUSTRY

SCHLEGEL MANUFACTURING COMPANY

1555 Jefferson Rd., Rochester 23, N. Y.
In Canada: Oakville, Ontario

Turbocharging has increased output by 9000 hp on 42 existing compressor installations of the Richfield Oil Corporation, such as this one near Bakersfield, California.

Power output of Richfield Oil Corporation's 2 cycle natural gas compressors has been economically increased 30-40 per cent by the AiResearch multiple turbocharger system . . . utilizing existing compressors, personnel and plant size.

At the same time, during the three years in which turbocharged units have been in operation, unscheduled down time and maintenance have been at a minimum.

In addition to long service life, the turbochargers in the AiResearch multiple system are smaller, easier to handle and less expensive to maintain or replace than a large turbocharger of a single unit system.

These rugged turbochargers have also accumulated many years of proven trouble-free operation in a wide variety of the most demanding vehicular applications. Extremely simple in design and requiring no separate cooling system, they are another example of AiResearch leadership in the development and production of air-cooled turbochargers and turbocharger controls for all major engine applications.

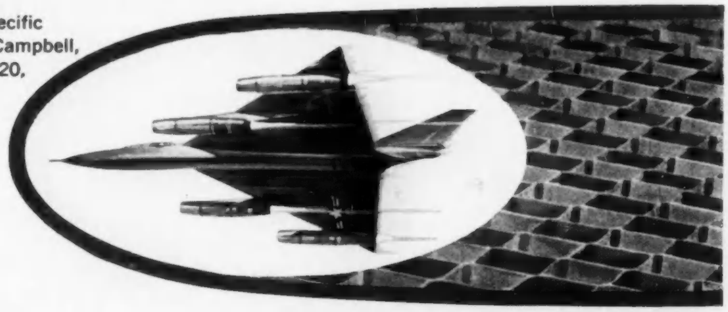
Your inquiries are invited.

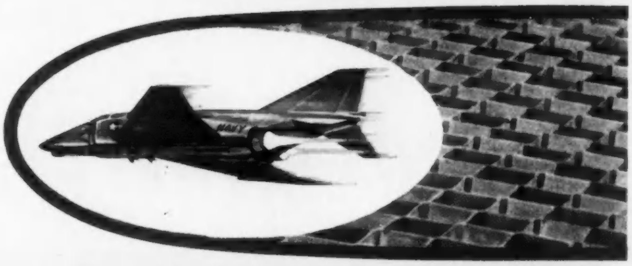
THE GARRETT CORPORATION

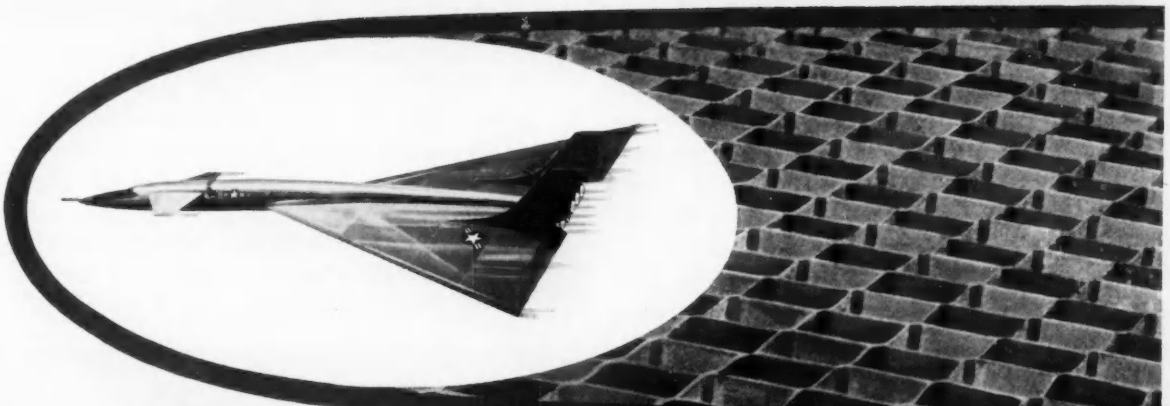
AiResearch Industrial Division

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS



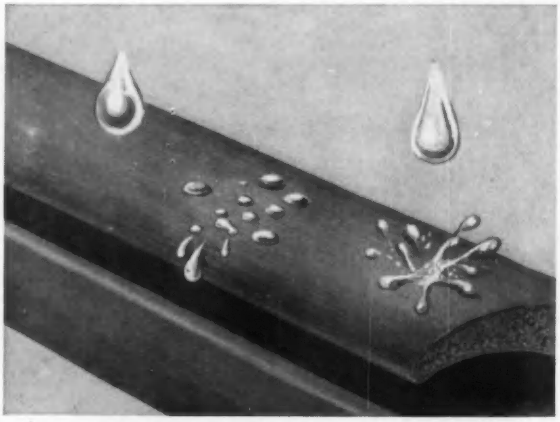




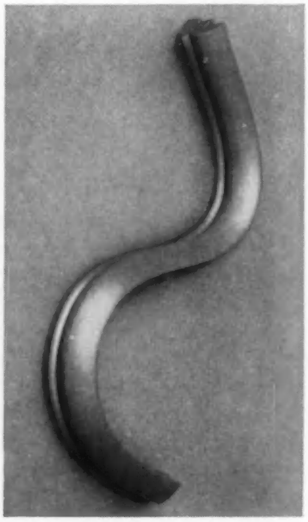
BRAKE ENGINEERS:

COMPLEX CROSS SECTIONS

WEATHER AND OZONE RESISTANCE



LOW WATER ABSORPTION



TIGHT RADII EASILY TURNED

EXTRUDED CLOSED CELL

NEOPRENE IMPROVES BODY SEALING

Only neoprene closed cell extrusions offer all these proven advantages as a body seal:

Excellent resistance to weather, ozone, aging, sun and oil.

Low water absorption; due to the characteristic closed cell structure, water absorption is held to a minimum . . . eliminates need for a veneer or coating.

Available in a variety of complex cross sections . . . adaptable to any closure design.

Tight radii easily turned without wrinkling.

Extruded closed cell neoprene is already being used effectively as a door and deck lid seal and as a hood lacing. Potential applications include roof rail seals, windlace and other body gasketing applications.

For more information on this new approach to body seal design, write for your free copy of our helpful brochure, EXTRUDED CLOSED CELL NEOPRENE.

E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department SAE-1, Wilmington 98, Delaware.

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Bundy can mass-fabricate practically anything

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In one place . . . at one time . . .
a world preview of engineering advances
in GROUND and FLIGHT vehicles

Plan to Attend the SAE International Congress and Exposition of Automotive Engineering . . .

. . . in Detroit's New Convention Center — Cobo Hall.

WHO IS COMING

15 thousand men charged with design and manufacture or selection and maintenance of passenger cars, trucks, buses, farm tractors, construction equipment, transport aircraft, missiles, space vehicles — and their components and materials.

WHAT'S IN IT FOR YOU

If you're one of them, set aside January 9–13 to acquaint yourself with current innovations in all fields of automotive engineering as they will be portrayed at the Congress and Exposition. Allow yourself time to tour the Exposition, look up your old friends and make new ones, and to participate in plant trips . . . SAE Annual Banquet . . . technical committee meetings . . . Fathers and Sons Night . . . annual business session of the Society . . . luncheon honoring foreign guests . . . meetings of any Activity Committees and administrative committees of which you are a member.

NONMEMBERS WELCOME

Nonmembers of the Society can attend the Congress and enjoy many of the advantages of membership temporarily by paying the registration fee of $3.00 per day or $12.50 for the five days. No fee for SAE members, of course, nor for members of the armed forces and other government employees, students, and faculty members.

WHY SO BIG

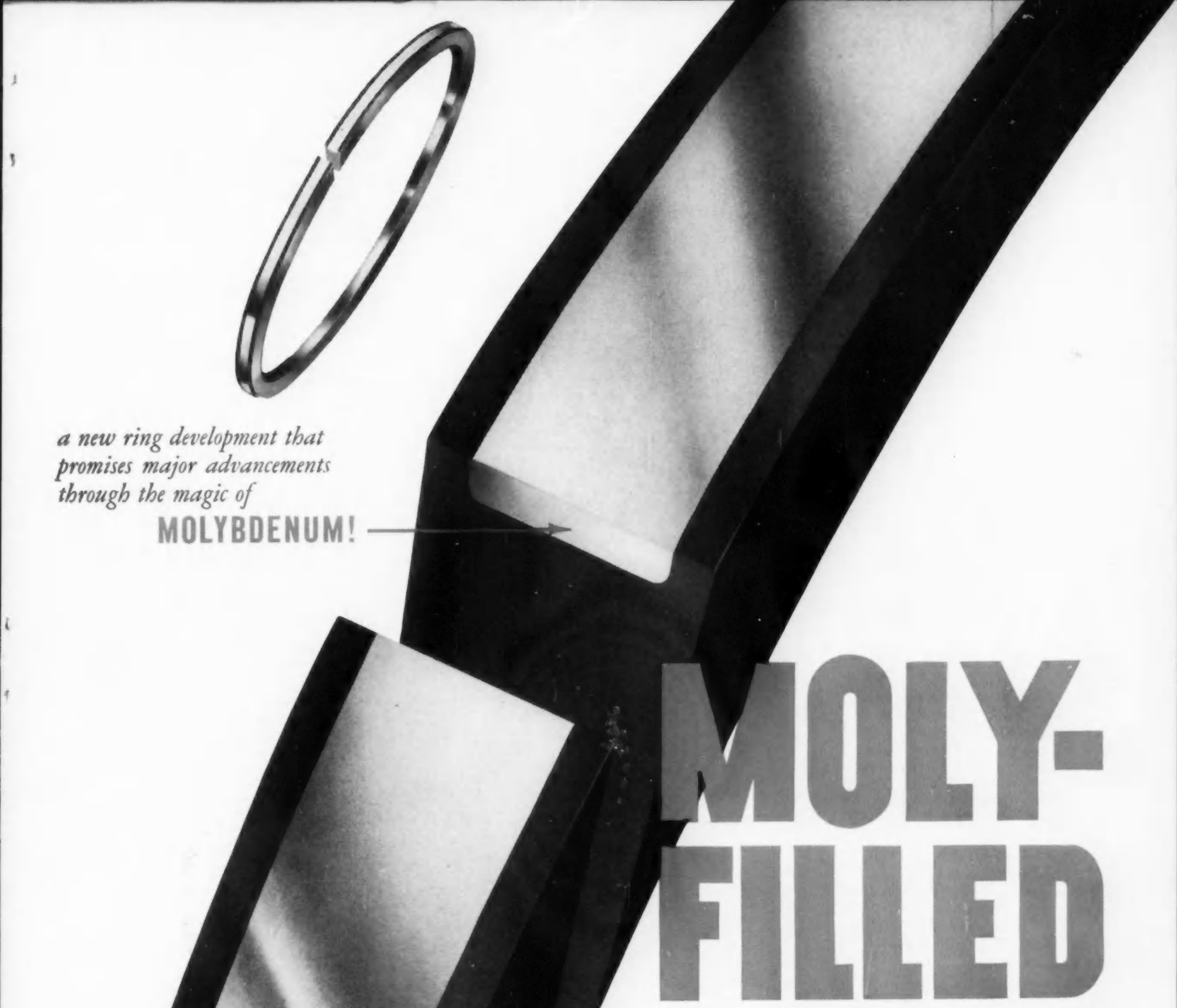
The opening of Detroit's huge new convention center, Cobo Hall, enables SAE to make its 1961 Annual Meeting the largest gathering of engineers concerned with self-propelling ("automotive" that is) vehicles of all kinds ever held under one roof. The expanded 1961 SAE Annual Meeting is being called the SAE International Congress and Exposition of Automotive Engineering.

LARGEST DISPLAY OF ITS KIND

Inspect the products and developments of the more than 300 exhibitors who will augment the technical program with the latest in manufacturing techniques, systems and components, materials and powerplants. In the 4½ acre display area, you'll have the opportunity to question the technical representatives manning these booths, and to get the answers to *your* problems.

FOR INFORMATION CONTACT:

MEETINGS DEPARTMENT
SOCIETY OF AUTOMOTIVE ENGINEERS
485 LEXINGTON AVE.
NEW YORK 17, N.Y.



a new ring development that promises major advancements through the magic of
MOLYBDENUM!

MOLY-FILLED

Cast Iron Compression Rings

A recent development of Ramco Engineering may soon obsolete many of today's compression rings. While still undergoing extensive testing in Ramco's laboratories, some of the findings are spectacular — particularly in friction reducing benefits.

Through a Ramco-developed process, the channeled face of a cast iron compression ring is filled with four to six thousandths of pure Molybdenum. The channeling leaves ten to twenty thousandths of cast iron at the top and bottom of the ring face. This means that the quick-seating qualities of cast iron are available and that the long wear characteristics of Molybdenum come into play for extra long life.

The Moly-Filled Ring is but one of the many new advances in ring design we'd like to show you. There are others equally interesting. A phone call or letter will put the facts on your desk.

Piston Rings by THOMPSON PRODUCTS RAMCO DIVISION

Thompson Ramo Wooldridge Inc. • P. O. Box 513
Dept. Q, St. Louis 66, Mo.

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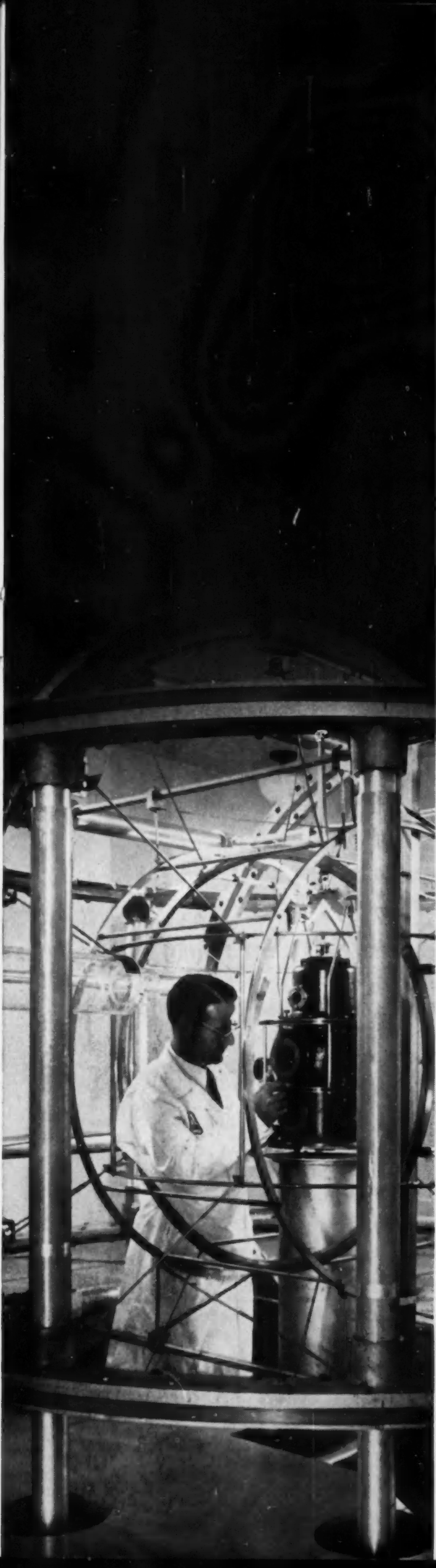


Why we eliminated the earth's magnetic field . . . almost

In an isolated laboratory in southwestern Ohio, GM Research scientists have reduced the earth's magnetic field to one ten-thousandth of its usual strength. This is about as weak as the interplanetary field detected by the Pioneer V solar satellite.

Why neutralize the earth's field? To perform with precision one of the more fundamental experiments in magnetism – measuring the Einstein-DeHaas effect. The measurement is simple in concept, experimentally difficult because of the tiny forces involved. It is made by suspending a ferromagnetic rod in a nearly field-free environment . . . magnetizing the rod . . . then measuring the effect (how much the rod rotates) when this known magnetization is reversed.

The beauty of the experiment is that the resulting values can be related directly to the motions of electrons in the rod. The values indicate the large portion of magnetization due to the *spin* of electrons . . . and the slight, but theoretically important, remaining portion due to *orbital* motion of electrons.

These measured values are helping scientists form a better understanding of the perplexing phenomenon – ferromagnetism. Currently being pursued in cooperation with the Charles F. Kettering Foundation, this long-standing project is one of the ventures in basic research of the General Motors Research Laboratories.

General Motors Research Laboratories

Warren, Michigan

Gyromagnetic Ratios

Iron	***a*** *1.92*	***b*** *1.90*
Cobalt	*1.85*	*1.83*
Nickel	*1.84*	*1.83*
Supermalloy	*1.91*	*1.91*

Comparison of (a) gyromagnetic ratios measured in the new Kettering Magnetics Laboratory with (b) corresponding ferromagnetic resonance measurements. These ratios would equal 2 if magnetization were due only to electron spin, or 1 if due only to orbital electron motion.

System of Helmholtz coils used to neutralize earth's magnetic field.

Some Ideas

for your file of practical information on drafting and reproduction from **KEUFFEL & ESSER CO.**

Six years ago, K&E introduced the very first polyester-base drafting film—a special-purpose medium featuring extreme dimensional stability. Experience with that film indicated that a definite need also existed for a *general-purpose* drafting film, if one could be perfected. About two and a half years ago we succeeded, introducing HERCULENE® Drafting Film—the first polyester-base medium for general drafting to meet professional standards. Many recognized its value immediately, stocked up on HERCULENE, and have used it happily ever since. Others—a bit more "canny" about adopting a relatively untried medium—deferred decision, saying "see us in a year or so." Still others—having tried one or more of the other films marketed immediately after HERCULENE—seemed permanently disenchanted with *all* film based media. What with the passage of time and much favorable ado about drafting films in general, we rather think that those once stung may now have adopted a more congenial attitude—so we address ourselves solely:

To fence-sitters everywhere . . .

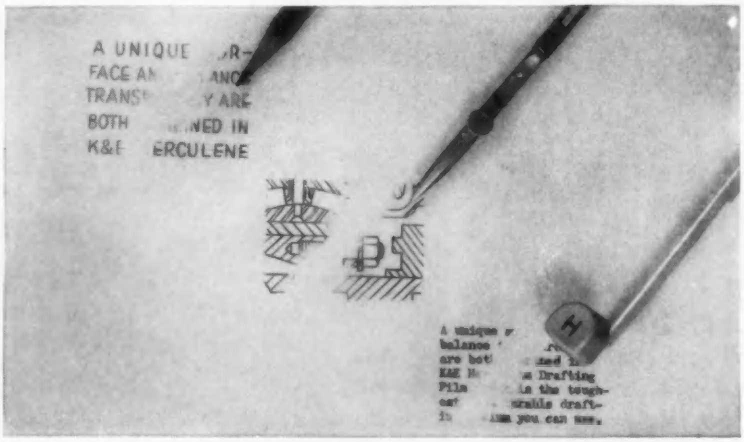
Just as we felt in '58, we feel today, that film has an important place in the drafting room. The only difference now is that experience has *proved* it so. Since 1958, the number of HERCULENE users has grown by leaps and bounds. All, we're happy to say, have found HERCULENE a welcome, efficient, and *much needed* addition to their stock of drafting media. It is these HERCULENE users who have written the record. Their many and rigorous tests, their months of experience, their numerous successes and continuing satisfaction are convincing evidence that HERCULENE is all we said it would be.

Why all the fuss about HERCULENE? . . .

HERCULENE combines practically all the qualities of a perfect drafting medium. An excellent product when introduced, it's even closer to perfection today. Working with major film users, K&E specialists have refined HERCULENE in many subtle ways since its introduction.

Unlike cloth or paper, HERCULENE is virtually indestructible. No matter how roughly or frequently a HERCULENE tracing is handled, it will never crack, wrinkle or fade. Absolutely waterproof, a HERCULENE drawing can never be permeated and ruined by moisture. Filed away, HERCULENE will last indefinitely. And HERCULENE has body, too, making it far easier to handle and file, and to keep flat on the drawing board.

Most of the refinements made in HERCULENE since 1958 have concerned its engi-



neered drafting surface. HERCULENE's surface "take" for pencil, ink and typing is now better than ever. Erasability, of course, is excellent for all three. Contrast has been built up for sharper definition of line, too, yet all the transparency necessary for fast, clear reproductions has been maintained.

Two big bonuses, too . . .

A significant chapter in the HERCULENE story has been the development of a waterproof writing mate—the Duralar plastic pencil. Drawings made on HERCULENE with this waterproof pencil can actually be

washed in soap and water. Even gray, grimy "unreproducible" drawings can be washed spotless with this new technique. Many firms now use the HERCULENE/Duralar team exclusively . . . and are realizing undreamt-of savings in costly re-draws.

Some firms, of course, by virtue of smaller work volumes and "cleaner" or less frequent handling, will have little need for this new wash technique. Of particular interest here is another K&E exclusive recently introduced—the amazing Ruwe pencil. The Ruwe pencil will not withstand washing, but in every other respect, this new pencil is graphite-*plus*. Although of plastic composition, the Ruwe pencil has all the "fine" feel of graphite, erases well, and deposits a sharp, dense black line. The big bonus: Ruwe pencil lines are *virtually smudge-proof*. Rendered on HERCULENE's engineered drafting surface, they actually resist smudging better than graphite on regular paper!

We leave it to you . . .

The best test remains the one you make for yourself. We've just completed a new brochure, titled "A Report on the Growing Acceptance of Polyester Film." In it is detailed most of what we have learned about HERCULENE and its use since 1958—including tests you can make to assess its every property. We'd like you to have a copy of this new brochure—plus a sample sheet of HERCULENE, a Duralar pencil, and a Ruwe pencil—for your own private testing. To get these free samples, simply fill out and mail the coupon below:

KEUFFEL & ESSER CO., Dept. SJ-1, Hoboken, N. J.

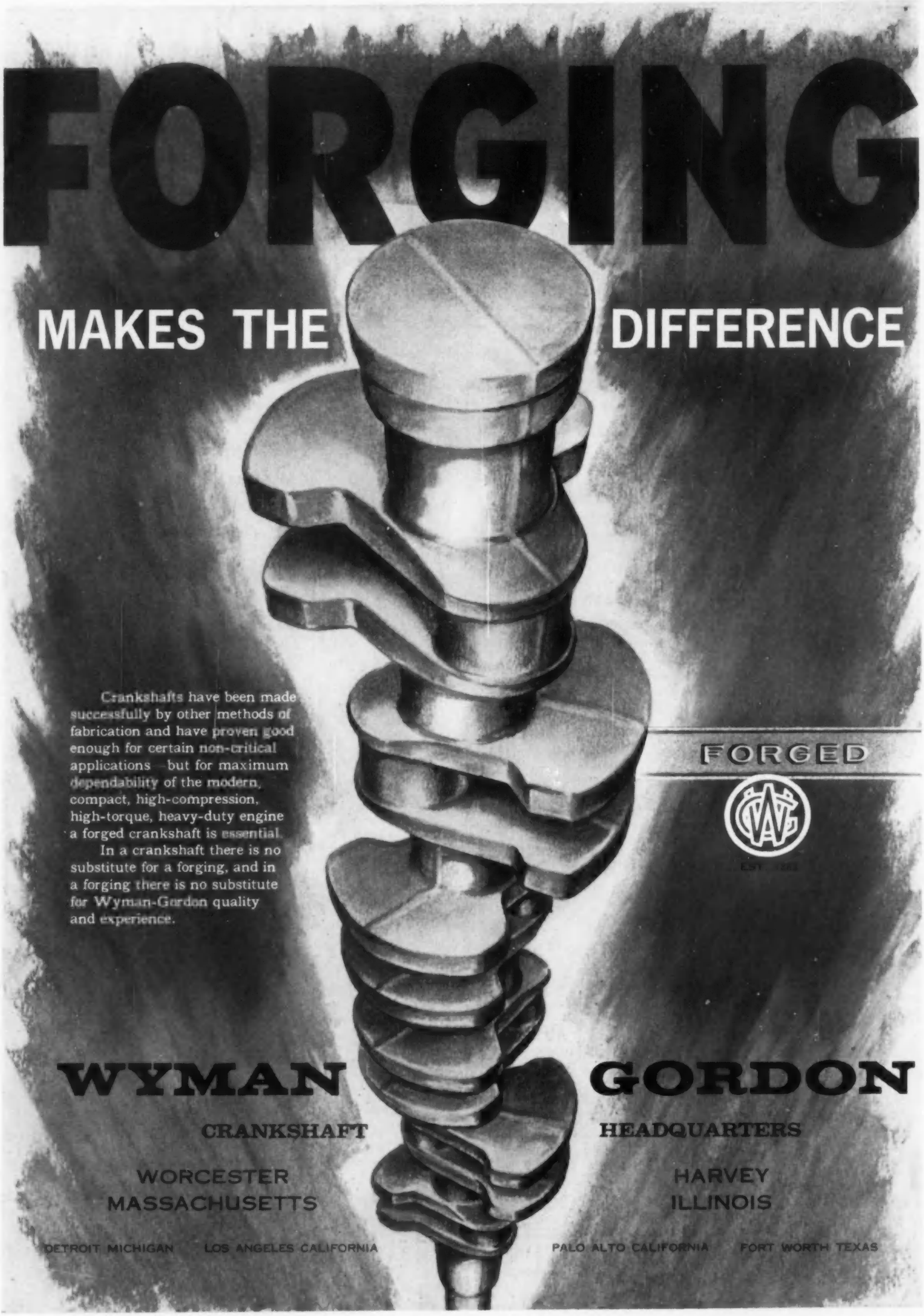
Gentlemen:

Please send me your new brochure, titled "A Report on the Growing Acceptance of Polyester Film," a sample sheet of HERCULENE Drafting Film, and samples of the Ruwe and Duralar Pencils.

Name & Title ____________________

Company & Address ____________________

____________________ 4031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Crankshafts have been made successfully by other methods of fabrication and have proven good enough for certain non-critical applications—but for maximum dependability of the modern, compact, high-compression, high-torque, heavy-duty engine a forged crankshaft is essential.
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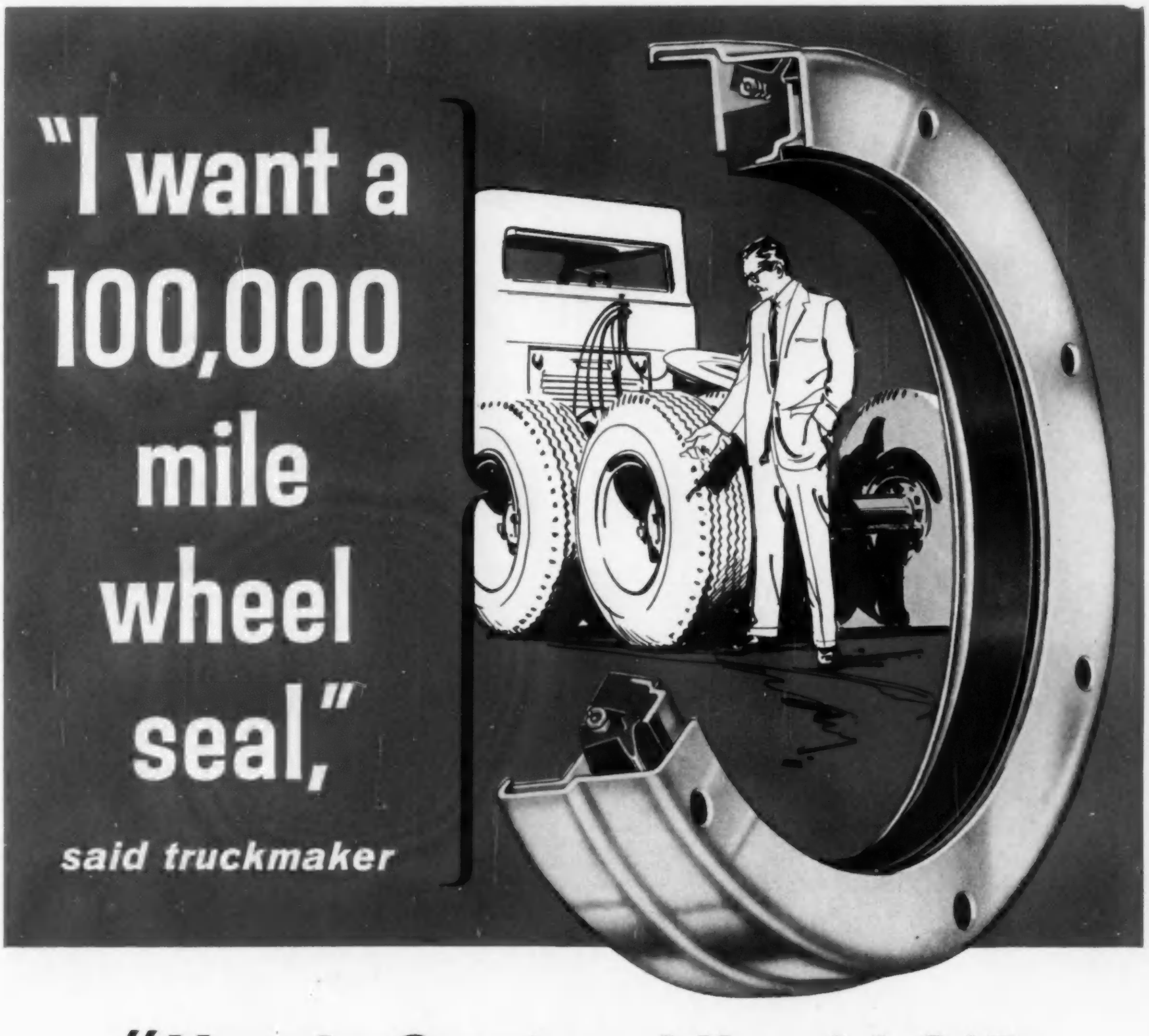

"Here's Scotseal," said C/R

Premature wheel oil seal failure—often within the warranty period—was plaguing a major truck manufacturer. This was costly. One seal replacement took three hours labor and three hours tractor downtime—important money to the maker, dealer and buyer. Then C/R found an answer to the problem. A unique, new design called the C/R Scotseal* was submitted and tested . . . then tested again and again. First result: C/R Scotseals repeatedly ran 100,000 miles and more with no sign of failure. Second result: they're approved now for every truck tractor this manufacturer makes.

Just why does this seal go 100,000 miles? C/R developed a special, ideal sealing surface and made it integral with the seal. The lip runs on this surface, *not on the shaft or bore.* In operation, centrifugal force creates positive, constant contact for leak-free performance. Also, the seal lip is completely encased and pre-lubricated, protecting it against damage in handling and assembly. This remarkable seal merits your consideration wherever high production runs are involved; where oil retention is difficult; and where equipment downtime and replacement costs are critical. The savings it can afford you and your customers may far outweigh the additional cost of this top-quality seal.

Write for your copy of C/R Scotseal Bulletin SS-100.*

CHICAGO RAWHIDE MANUFACTURING COMPANY

OIL SEAL DIVISION: 1243 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
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Export Sales: Geon International Corp., Great Neck, New York

C/R Products: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts
Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.

*Reg. U. S. Pat. Off.

AiResearch GPV-91 gas turbine and 120 KVA alternator ground power unit

This single AiResearch ground power package provides all the electrical and pneumatic power needed to meet the increased ground support requirements of the newest jet transports. At the same time, the new dual-purpose GPV-91 results in a unit that effects considerable dollar savings over separate units to provide pneumatic starting and electrical services.

The 120 KVA power package doubles previous electrical output of support systems to supply all power for ground checkout and heating . . . and enables Freon refrigeration systems to operate at maximum capacity during the entire ground operation in hot weather.

The compact power unit consists of an AiResearch GTCP 85-91 gas turbine driving a 120 KVA alternator. This gas turbine features automatic operation and pushbutton starting, operates in any weather extreme from −65° to 130°F. Optional 28 volt dc power is available up to 1600 amperes.

This lightweight power package can be installed on nearly any vehicle or carried as an onboard unit. AiResearch has delivered more than 9000 gas turbines in the 30 to 850 hp range, and is the world leader in producing turbine ground support for airliners.

Please direct inquiries to Los Angeles Division.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

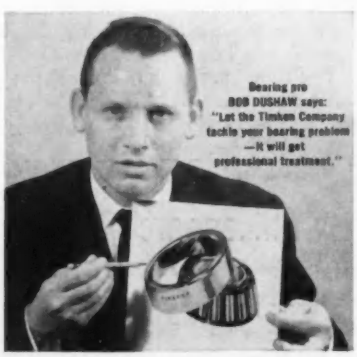
Remember when . . .

DOAK WALKER PROVED HE WAS AN "OLD PRO" IN HIS FIRST YEAR

He took a pass for 33 yards. Then a pass for 20 yards. Kicked an extra point. Then a 35-yard field goal. And eight more yards on a pass for the winning touchdown. That was a big day for Doak Walker—against Green Bay, November 19, 1950. And he went on to lead the league in scoring in his rookie year!

Some men show they're pros right from the start. It's their ability and determination that sets them apart.

In sports, and in bearings, the pros come through when the chips are down. You'll see it whenever you work with a Timken bearing engineer. They're picked for their winning qualities, trained by other pros—and they're proud of their company. Proud of giving the best bearing engineering service in the industry. Proud of the world's most modern bearing plant that gives you lower bearing costs. And they're proud of the fine precision manufacture of Timken bearings that guarantees top professional performance.



The Timken Company's entire history is one of pioneering just one kind of bearing—the tapered roller bearing, the most economical bearing you can use. We know more about this bearing than anyone else. The Timken Roller Bearing Company, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

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from the pros of the bearing business

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